# RADIO and ELECTRICAL Review

TELEVISION - COMMUNICATIONS - SERVICE - SOUND

Incorporating "RADIO and ELECTRONICS"

AUGUST, 1st 1955

VOL. 10, NO. 6

PRICE 1/10

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# Radio and Electrical Review

VOL. 10, NO. 6 AUGUST 1st, 1955

OUR COVER:

A fitter checking a British electronic high-speed sorting machine manufactured by Sigma Instruments Ltd. to be used in Italy for checking the length and diameter of steel rollers for bearings to 1/500,000 of an inch at the rate of 5,000 an hour.

Official Journal of
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The N.Z. Radio and Television Manufacturers' Federation.
The N.Z. Radio and Electrical Traders' Federation.
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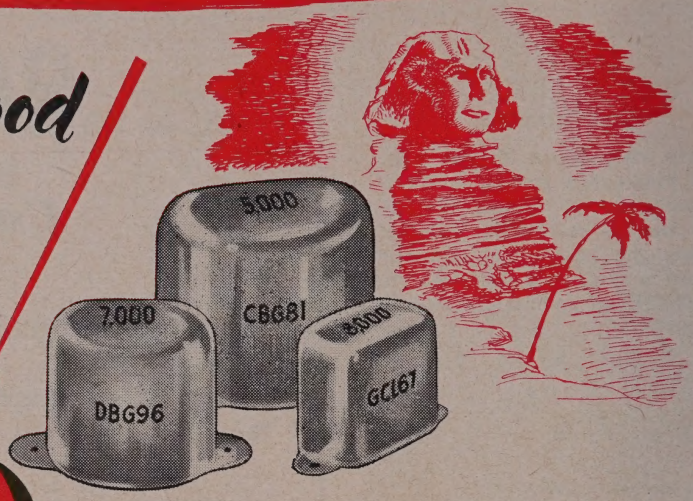


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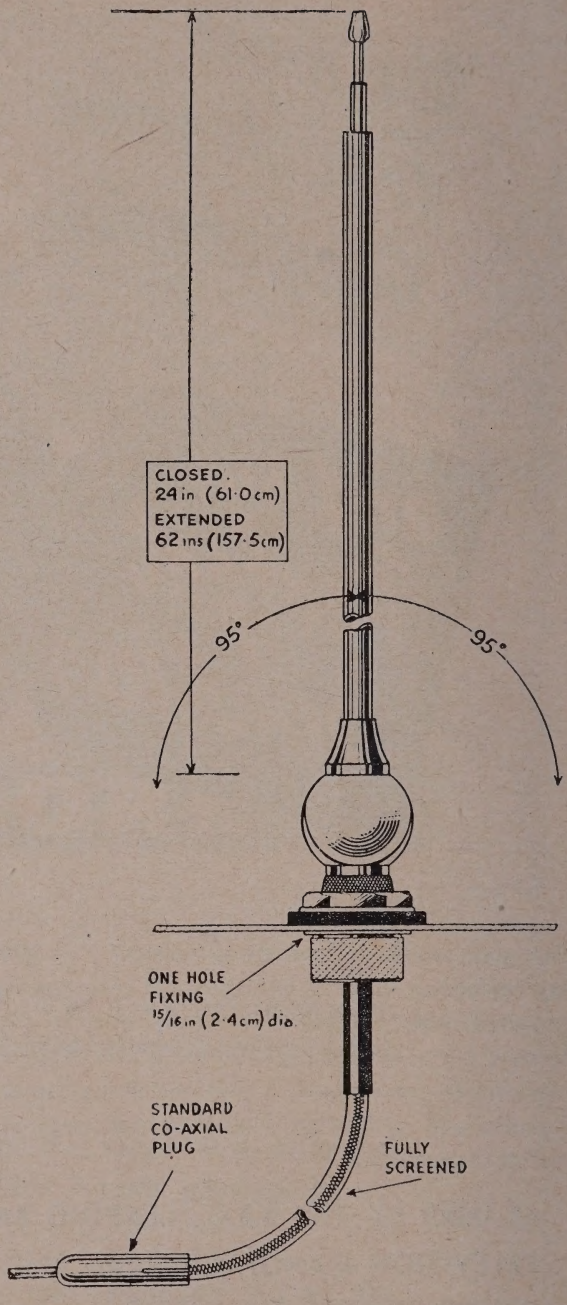


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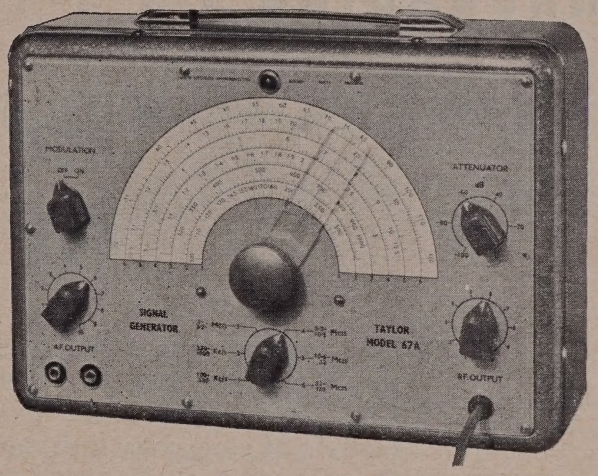


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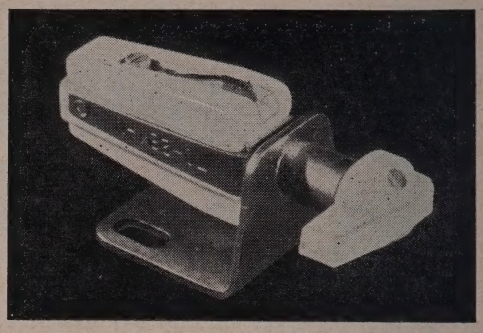

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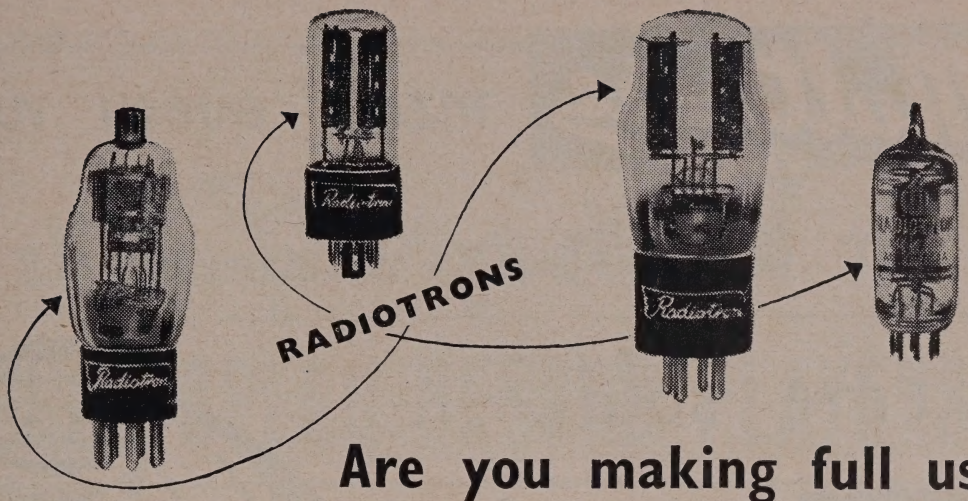


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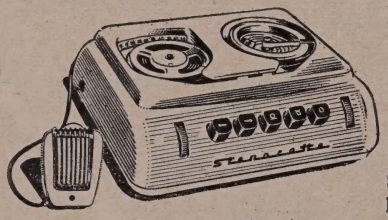

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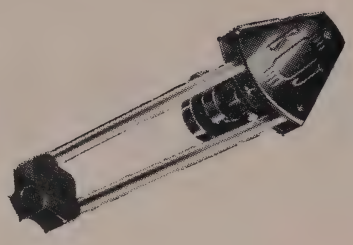

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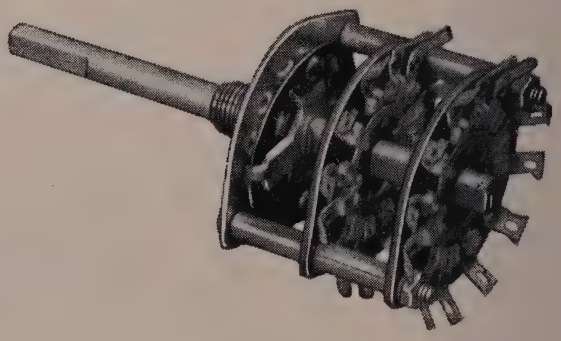

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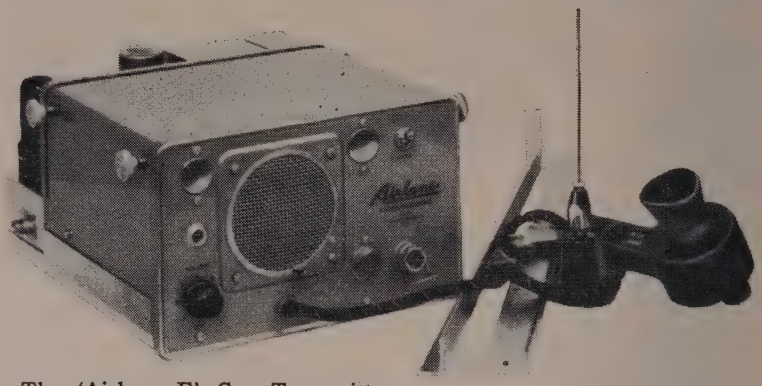

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★ Simply operated—merely turn a switch to record your favourite radio programme — faithfully balanced and reproduced.

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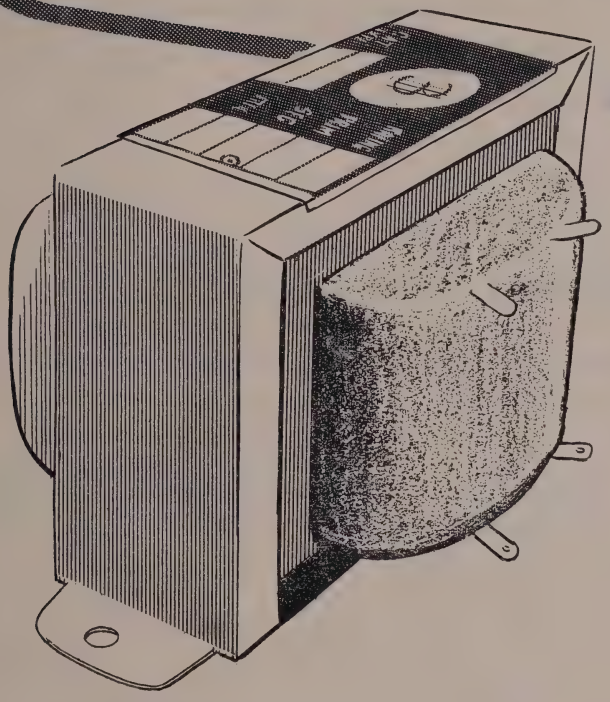

PRIMARY

Cat. No. 50S56 ..... 5,000 ohms P to P
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Primary Inductance @ 1,000 c/s. 70 henries.

Primary Resistance ..... 350 ohms.
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3·7 ohms (parallel) or 15 ohms (series)
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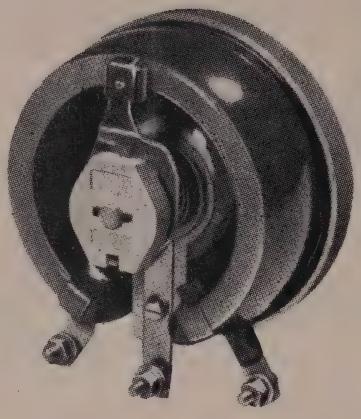

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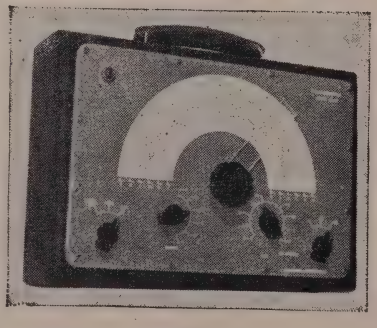

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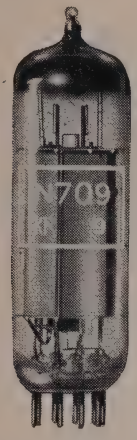
Osram VALVES

# Pointers for Designers

AND CONSTRUCTORS
NUMBER FOURTEEN



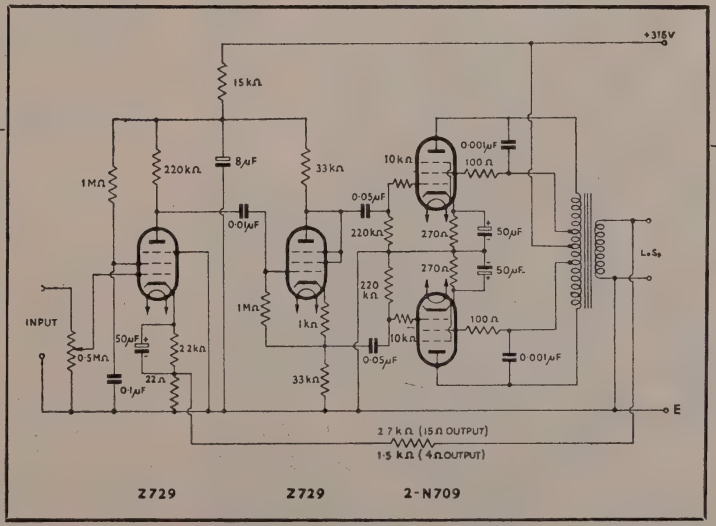

## N709 OUTPUT PENTODE

### "ULTRA-LINEAR" OPERATION

The diagram illustrates the circuit of a simple and economical 14 watt high quality amplifier using two Osram N709 output pentodes preceded by two Z729 low noise pentodes.

The distortion is extremely low, not greater than 0.1% at 11 watts and only 0.5% at full output, for which an input of 150 mV r.m.s. is required. The output transformer should be of good quality, with a primary inductance of 80 H, and a leakage inductance not greater than 100 mH. The screen tapping points include 20% of the turns of each half primary, counting from the centre-tap. The anode-to-anode load is 7 kΩ.

With the moderate degree of overall feedback employed this circuit is both stable and trouble-free in operation.




Further information can be obtained on application to The Osram Valve and Electronics Department

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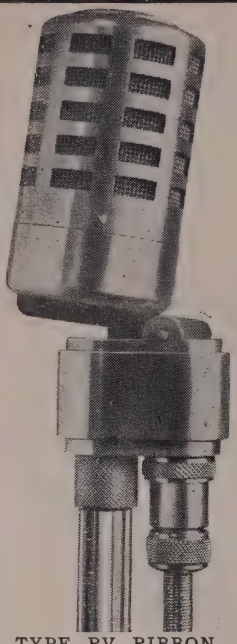
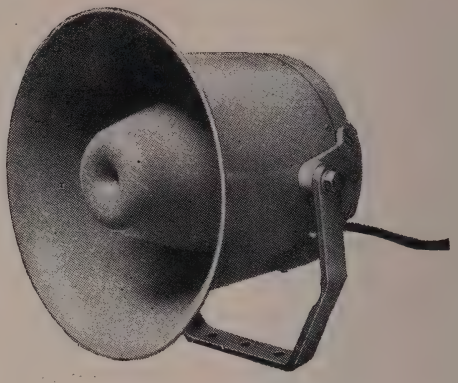
# Reslo MICROPHONES and WATER PROOF REFLEXED SOUND PROJECTORS



TYPE RV RIBBON MICROPHONE



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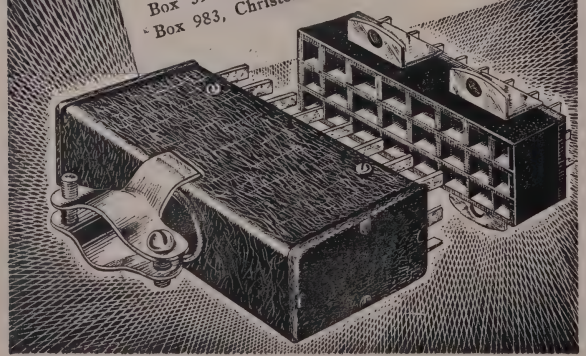

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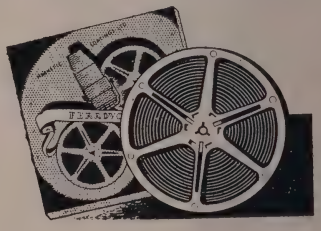

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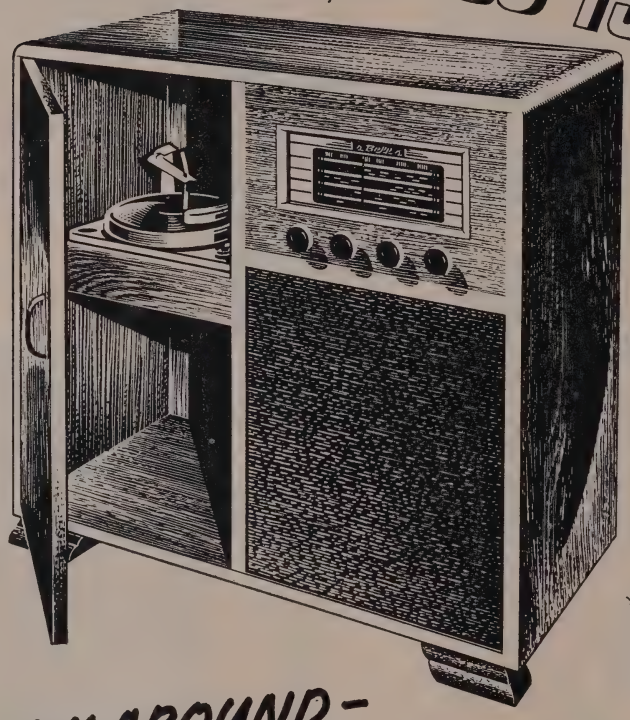

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# TV A Step Nearer?

It seems a long time now—and it is almost two years—since the Government decided that nothing should be done about television in New Zealand. At the time, the decision was somewhat of a blow to the radio industry, which had been waiting hopefully for a sign that a start might be made in the near future. It is obviously of vital importance to the industry that any planning of the country's service should be done well in advance. For everyone engaged in manufacturing radio sets today, the final advent of TV will represent a tremendous upheaval. Staff will have to be trained, factory space will in most instances have to be enlarged, new capital will have to be found in many cases, and so on.

For the New Zealand Broadcasting Service, upon whom some or all of the responsibility for TV transmissions and programmes will devolve, television when it comes will be even more of a revolution. It is a good deal more than two years since the N.Z.B.S. made an examination of the technical side of TV, as it existed at the time, and made recommendations as to the standards that should be adopted in this country; since that time, a good many changes have come over the international television scene. A great deal of development has been done on colour television, for example, and, while it is extremely unlikely that in the first instance New Zealand television should be even partially in colour, the status of colour development may well have a bearing on the choice of technical standards—and this is a matter of the utmost importance. Again, it is obvious that in this country all possible steps will have to be taken to ensure that maximum possible use is made of what programme material is available. This means that simultaneous transmission of programmes from the stations in the main centres would be very desirable in the interests of running economy. Again, it is unlikely that network operation of several stations will be possible at first, owing to the high capital costs that would be involved in providing the necessary technical facilities, but here again we have a problem, the root of which lies in contemporary technical development. To the public, the methods used for achieving long-distance hook-ups between television transmitters are of little direct interest, but it is a fact that this phase of television technique could, and probably will, have an important bearing on the standards to be adopted, and even on the date at which TV is introduced.

These, and other factors, make it very desirable that the whole question should be reviewed, both technically and otherwise. They also emphasize the fact that some of the essential decisions on matters of policy should be made as soon as possible. Approximately two years must normally elapse between any decision to go ahead with television and the commencement of a service, and it seems to us that further delay could cause considerable difficulty to those who will have to implement a policy, once one has been formulated.

It was therefore with some surprise, and considerable pleasure that we read the recent statement in his Budget speech by the Hon. R. M. Algie, Minister of Broadcasting. Quoting from the Press report: "The time was about opportune for re-opening the question of television and of re-assessing the position in order to find out whether anything might be done towards providing for a general pattern which such a service might follow."

Mr. Algie said that he would frankly plead guilty to having gone rather slowly in the matter —deliberately. He outlined technical problems which would have to be faced before the introduction of a television service could be proceeded with.

Unfortunately, we did not hear Mr. Algie's speech in the House, and thus are unable to amplify the last sentence from the above quotation. It seems not unlikely, however, that he was referring to decisions that will have to be based on current developments overseas. The main thing is that in the Minister's speech we have an indication that television has not remained altogether forgotten by the powers-that-be. Let us hope that here we have a further step forward—albeit a small one—and that the Government from now on will cease "marking time," as Mr. Algie put it.

*Audio*

# SQUARE-WAVE TESTING OF AUDIO AMPLIFIERS

*While much has been written in technical literature overseas on this topic, this is the first time that "Radio and Electrical Review" has dealt with it. Results are shown in the form of photographs, direct from the oscilloscope face, and have been taken for a number of well-known commercial amplifiers, as well as for some designed and built in our own laboratory.*

## INTRODUCTION

Relatively speaking, the testing of amplifiers by means of square-waves is a new process. The time-honoured methods of testing have all made use of sine-waves, and with the exception of intermodulations tests are therefore all of the single-frequency variety. Engineers have realized for long enough that single-frequency tests can bear very little relation to listening tests, and it is for this reason that inter-modulation testing was developed. Even this form of test, however, is little more than a more sensitive way of measuring distortion, and can be performed in so many ways that the results do not mean very much, except by comparison with other tests taken in an identical manner. While it is true to say that inter-modulation testing is a step in the right direction, and can give results which correlate well with listening tests, it is by no means the final answer, and a persistent search still continues for a scientific method of amplifier testing which will tell without ambiguity whether one amplifier will sound better or worse than another.

No one would claim that square-wave testing contains the answer to this difficulty. At best it is another approach to the same old problem, but it does have the advantage that it will reveal about an amplifier charactertistics that cannot be compared in any other way, and which cannot even be guessed at by any other method. If there is any test method which can tell us without doubt that an amplifier will sound well when reproducing music, it is square-wave testing. For this reason, we thought readers who have not the facilities for making such tests would be interested to see the kind of result that can be obtained by this method, and how searching the tests really are.

## WHY DO SQUARE-WAVE TESTS?

Apart from the above, there is a story behind this article. In the course of preparing the series of lecture-demonstrations which we gave recently in Wellington, we assembled a mass of equipment such as is seldom found anywhere in one place at the one time. Among other things, we had samples of all the well-known proprietary makes of amplifier that are on the New Zealand market today, not to mention two amplifiers of our own design and construction. There were six push-pull amplifiers, all with some claims to high-fidelity characteristics, and one single-ended commercial amplifier which is being sold as a gramophone amplifier. Disregarding the latter for a moment, a perusal of the makers' published specifications showed that all these amplifiers claimed frequency response from 20 to 20,000 c/sec., and all claimed distortion below 0.2 per cent., while some claimed less than 0.1 per cent. All gave power output ratings.

Now when we have a number of amplifiers whose specifications, as outlined above, indicate such excellent performance, one might legitimately expect, when listening tests are conducted, using identical programme material, and the same pick-up and speaker system, that all the amplifiers sound the same. It was with considerable surprise that we found exactly the opposite. Three of the seven amplifiers did sound identical, and this in spite of the fact that the three were used with pre-amplifier circuits that differed widely. The differences could therefore not be attributed to differences between the pre-amplifiers, and their methods of obtaining record compensation. This leaves the main amplifiers themselves. The first notable point was that the two amplifiers whose sound we liked least employed some form of "ultra-linear" operation of the output valves, while those which sounded best had straight triode operation of the output stage. At first, in an attempt to be quite fair, we accused ourselves of being prejudiced against the "ultra-linear" arrangement, but further listening quite confirmed the first impressions. Indeed, the first indication we had of any one amplifier sounding less pleasant than the others was when we were trying out a new type of pick-up. At first, the "nastiness" we could hear was put down to the pick-up itself, until it was realized that at the same time, we were using an amplifier which we had not previously heard. It was a simple matter to change over the pick-up to one of the amplifiers we considered to be satisfactory, whereupon the unpleasantness disappeared. Cross-checking then indicated that what we were complaining about was the amplifier, and not the pick-up at all.

Having proved to our own satisfaction that we *could* detect differences in the sounds made by different amplifiers, some further testing was undertaken. The other ultra-linear amplifier was found to sound very similar to the one to which we had first taken a dislike, while the remaining four triode-connected amplifiers were indistinguishable, as far as we could tell.

Here we should point out that these listening tests were undertaken on what is probably the best loud-speaker available, and which certainly makes the best reproduced music we have yet heard. At the same time, we had been performing a series of highly critical listening tests on a large number of records, and on other equipment as well, so that our own critical faculties were undoubtedly sharper than usual. The differences we could hear were thus not necessarily as marked as could be noticed by many other people, for to spot differences of this order requires not only what is usually described as a "good" ear, but also considerable practice. In other words, we could regard our own perception as certainly sharper

than that of the average listener. This has been mentioned here, only to emphasize the point that the amplifiers whose sound we did not like would probably not be heard once and rejected out of hand by the average listener. Our complaints were not as serious as that. Nevertheless, the unpleasantness complained of took the form of a hardness in the middle and upper register—the kind of hardness that used to be associated with pentodes without negative feedback, but of course not nearly so violent or objectionable in this case.

Having got thus far, it was clear that some investigation was called for, to try to find out whether any technical tests would show up possible reasons for our listening preferences. Assuming therefore, as a first approximation that the makers' specifications as to frequency response and distortion are correct, there seemed little likelihood that any tests along these lines would prove anything. Square-wave testing, on the other hand, might very well be the answer, because they are so much more searching than single-frequency tests with sine-wave.

## WHAT CAN BE EXPECTED FROM SQUARE-WAVE TESTS?

In the preceding paragraphs we have cited in detail some of our own experience, not because it is ours, but because it illustrates rather well the fundamental reasons (or some of them) for performing square-wave tests at all. In short, square-waves should show up aspects of amplifier performance that no amount of sine-wave testing will detect.

Now the basic objection to sine-wave tests is that they are not sufficiently related to the conditions that obtain in real life, by which we mean that one does not assemble sound-reproducing equipment for the purpose of listening to sine-waves. In practice, we listen to music. It may be argued, of course, that neither do we listen to square-waves, and neither we do, but the fact remains that square-waves are very closely related to certain very important aspects of musical reproduction, about which sine-wave tests will tell us absolutely nothing. The question is one of transient response. A transient phenomenon is usually defined as one which occurs only at infrequent intervals, and which may occur only once, never to be repeated. Such phenomena include what is musically known as "attack", which is bound up with the rate at which changes in amplitude occur. For instance, when an organ note is sounded, the air vibrations inside the organ pipe build up relatively slowly, and the instrument is said to have a slow attack. On the other hand, when a gong or a cymbal is struck sharply, there is an almost instantaneous build-up of sound from nothing to a very large amplitude. It is obvious therefore that not only must reproducing equipment be able to give distortionless reproduction of steadily-sounding tones, but it must also be able to initiate them as quickly as they occur in the original sound. Similarly, when sound suddenly stops, the amplifying gear must not carry on, but must cease as quickly as did the original sound.

The square-wave can be regarded as a repetitive series of transients, each transient being the almost instantaneous rise or fall, so that if the amplifier is able to reproduce square-waves accurately, it should be able to respond well to any transients found in music—and there are plenty of them. In practice, it is found that no amplifier reproduces with absolute fidelity square-waves of all frequencies. In theory,

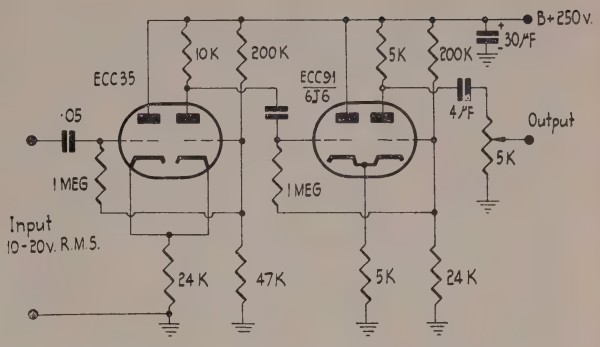


FIG. 1.—*Circuit of the square-wave generator used for the tests. The unmarked coupling condenser does not have to be large—0.1mfd. was used in this position. This circuit can be made up as an add-on unit for any oscillator.*

a perfect square-wave requires a level response from zero frequency to infinity c/sec., if it is to be perfectly reproduced. Fortunately, a perfect square-wave does not exist to start off with, but the fact remains that a square-wave requires a very wide frequency range in any amplifier which attempts to reproduce it. Thus, square-wave tests will to some extent show up the frequency response of an amplifier as well as showing what happens when it is excited by transients. Perhaps the best way of illustrating the point is to show some actual oscilloscope pictures, so we will leave the matter for the moment.

## CONDITIONS OF TEST

A square-wave generator was used consisting of a laboratory audio oscillator, followed by a specially-built squaring circuit, shown in Fig. 1. The output waveforms of the generator are shown in Fig. 2 for three frequencies. Reading from top to bottom, they are 30, 400, and 10,000 c/sec., respectively. In order to make the comparisons as valid as possible, these photographs were taken after the square-waves had been passed through the wide-band oscilloscope amplifier which was used in testing the audio amplifiers.

In testing each amplifier, the following procedure was used:

(1) A sine-wave at 400 c/sec. was fed to the amplifier, and the amplitude was adjusted to the amplifier overload point, as observed on the 'scope. The input was then fractionally reduced, in order that there should be no doubt of the amplifier's being worked within the sine-wave power output of which it was capable. The size of the pattern in the vertical direction was then taken as a measure of the peak-to-peak amplitude that the amplifier could be expected to handle.

(2) The square-wave generator was then fed to the amplifier input. The amplitude was adjusted to give the same peak-to-peak output amplitude as had been set up in step (1), and the trace was examined.

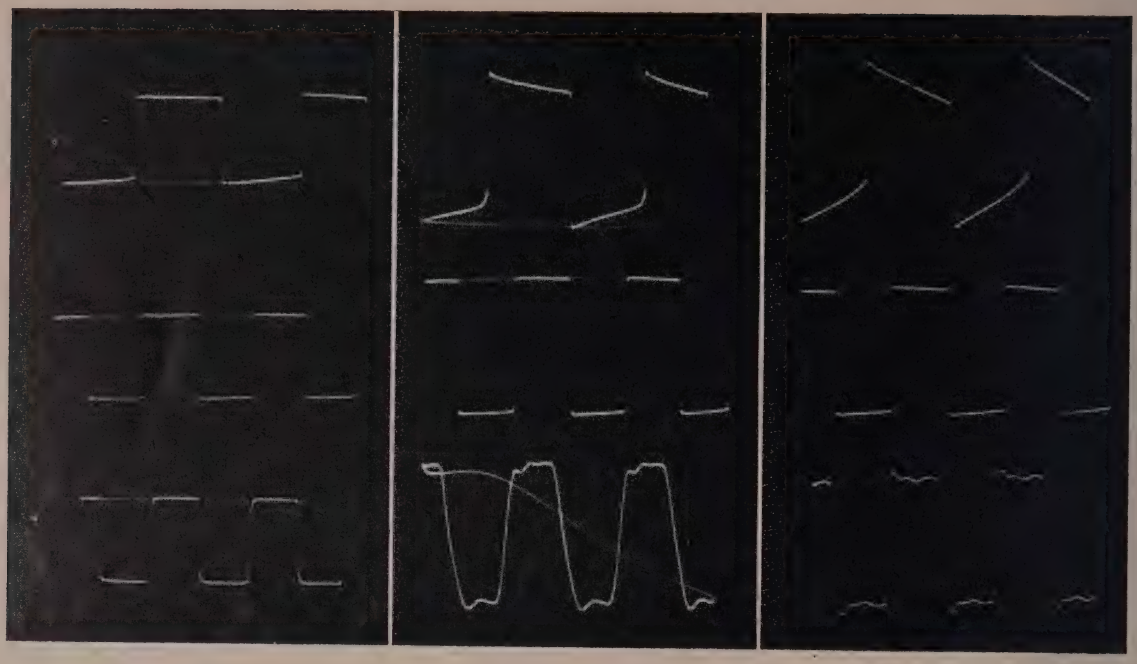

FIG. 2. FIG. 3.—*Amplifier A.* FIG. 4.—*Amplifier B.*

FIG. 2.—*Waveform of the test generator at the three frequencies used. Reading from top to bottom we have 30c/sec., 400c/sec., and 10,000c/sec. In the remaining figures, the three frequencies are the same.*

(3) The square-wave generator was set successfully to 30 c/sec. and 10,000 c/sec., and the resulting traces were examined.

With some of the amplifiers, it was found that the above procedure could be followed exactly, and the resulting square-waves at the three frequencies were photographed. Other amplifiers, however, clearly would not handle without severe distortion a square-wave having the same peak-to-peak amplitude as the maximum peak-to-peak sine-wave amplitude they would reproduce. In these cases it was necessary to reduce the square-wave input amplitude to a point at which no marked changes in output waveform occurred as the amplitude was increased from zero. This point was taken as the maximum "undistorted" peak-to-peak square-wave amplitude that the amplifiers would handle, and was the level at which photographs were taken in such cases.

## GENERAL RESULTS

Perhaps the most important single result has been stated in the last paragraph, namely that some amplifiers are incapable of reproducing transient amplitudes approaching the sine-wave amplitudes that they will handle. It is obvious that an amplifier which *will* handle the same p-p amplitude irrespective of waveform, is better than one which will not. This is an excellent example of the traps into which sine-wave ratings can lead us. For example if distortion of transient signals has an audible effect on reproduction quality (and there is evidence to show that it has) there is a good case for rating the power output of amplifiers not, as now, on the basis of its ability to handle sine-waves, but on some basis related to its ability to reproduce square-waves. This is amply illustrated by some of the test results obtained and pictured here. One amplifier (amplifier A, of Fig. 3) produced a sine-wave output power of 6 watts from the output valves, and at the secondary of the output transformer, in to a 15 ohm resistive load, 4½ watts. This amplifier would handle a peak-to-peak square-wave equal in amplitude to the p-p sine-wave output which produced the power of 4½ watts at the voice-coil. In other words, it would handle the same p-p signal amplitude irrespective of waveform.

Another amplifier (amplifier E, Fig. 7) would handle a square-wave of only 0.54 times the amplitude represented by the maximum sine-wave power output. This means that its maximum output power with square-wave input was only $0.54^2$, or 0.29 of the maximum that it would have given, had it been able to handle the square wave at full amplitude, as amplifier A did.

Another way of expressing the difference between these two amplifiers would be to define a quantity "Equivalent Sine-wave Power", and to use it as a measure of the power handled by the amplifier at the reduced level where it is just not overloaded by the square-wave. Then, this equivalent sine-wave power could be used as an indirect measure of the ability of the amplifier to reproduce transient phenomena.

While it is not suggested that such a measurement can by itself define the transient performance of an amplifier, it could do if used in conjunction with a set of oscilloscope patterns such as the ones illustrated in this article.

The effect of rating amplifiers in this way would be

FIG. 5.—*Amplifier C.*

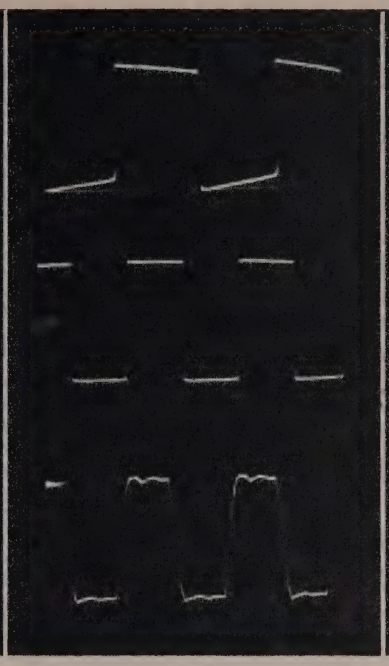

FIG. 6.—*Amplifier D.*

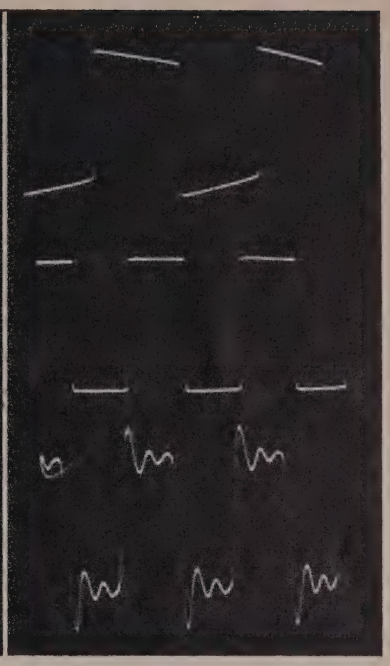

FIG. 7.—*Amplifier E.*

to drastically reduce the rated power of those with poor transient response, and so to encourage makers to improve their products. As we have said, it is somewhat surprising at first to find that commercial amplifiers claiming a very low order of distortion are in fact far from ideal, but the more one thinks about, the more closely it is realized that the square-wave test is far more closely related to actual operating conditions than are conventional test methods. Indeed, the sine-wave test clearly bears little relation to the real "facts of life."

The second conclusion is that there is some relation, if not a particularly clear-cut one, between listening tests and square-wave performance. The amplifiers A, B, and D (Figs. 3, 4, and 6) were three which sounded very well, and indeed identical in general character. All three had frequency response curves which showed insignificant falling off over the audible range, and appreciably beyond it at each end, but the differences between them are readily discernible in the photographs. The best, at both low and high frequencies, is D (one of the commercial amplifiers).

FIG. 8.—*Amplifier F.*

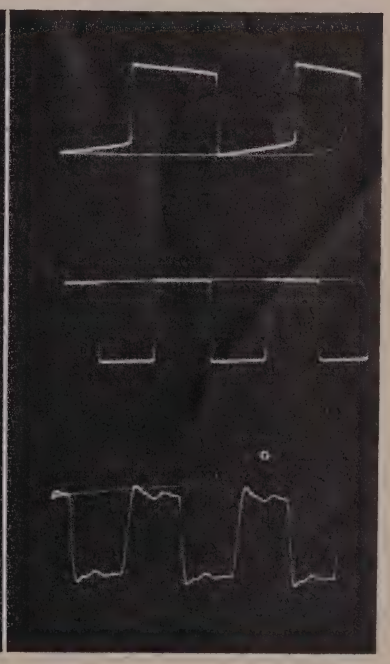

FIG. 9.—*Amplifier G.*

The other two are still good, however, and the most important point is that *these three are the only ones which did not have to have the output considerably*

*reduced in order to avoid overload distortion when the square-wave was substituted* (at the same p-p amplitude) for the initial setting-up sine-wave. All the others showed faults of one kind or another which made it necessary to reduce the input, and therefore the output voltage before the best square-wave reproduction was achieved.

To illustrate how "tough" square-wave tests are, let us examine the performance of the amplifiers at low frequencies. The droop of what are supposed to be the flat tops and bottoms of the square-wave is present in greater or lesser degree with all of them. This is quite normal, and only to be expected however excellent the amplifier may be. It can be eliminated only by extending the flat response at the low frequency end of the scale down almost to zero frequency. In this respect, then, the photographs show that the method of testing is possibly too sensitive as regards low frequency response, since the differences were probably negligible. Certainly it was impossible to detect any audible difference between the three preferred amplifiers in this respect. Of the three, D has the best performance, followed closely by A and then by B. It is worth noting that the droop is caused by phase shift rather than by lack of amplitude response. A slightly convex curvature, as shown by E at 30 c/sec. means a rising response in the extreme low frequencies, while the droop shows a leading phase angle, such as is produced by normal RC couplings. A slight concavity, as shown by A means a steady roll-off in frequency response, also allied to the phase shift, as evinced by the general droop. An amplifier with a pronounced low-frequency rise, such as occurs sometimes when there is only a small margin of stability, when a little more feedback would cause motor-boating, or very-low-frequency oscillation, would give an increasingly convex top to the square-wave.

At the high-frequency end, the effects to be noticed are quite different. Droop does not occur, even at middle frequencies, as all but one of the 400 c/sec. waveforms show, but instead there are to be found various forms of ringing. The best illustration of this was provided by amplifier E.

This exhibits what is known as overshoot. That is to say, the output waveform does not stop rising, suddenly, as it should, but carries on rising. The shock of the very steep rise excites the amplifier into a damped oscillation, which is very well marked in E. In general, an amplifier which overshoots on a fast transient voltage change will not subside suddenly to the correct level. The waveform oscillates for several cycles before coming to rest at the proper level. This damped oscillation must occur if there is overshoot to begin with, and some degree of overshoot and therefore of "ringing" can be expected with every amplifier. The better the characteristic of the amplifier, however, the smaller will the overshoot be, and the more heavily damped will be the ringing. Amplifier D shows excellent performance in this respect, while E is not nearly so good. Indeed it is this very marked overshoot which prevents this amplifier from handling transients of the same peak amplitude as the sine-waves it will reproduce. The overshoot is additional signal amplitude, put there by the amplifier itself, so it is only natural that if the amplifier's output valves are not to be run into grid current, or to cut-off, the signal amplitude must be reduced below the maximum sine-wave level.

Amplifiers A and B also show good high-frequency performance, although there is some evidence in the former case that the valve characteristics are not quite matched, or else that the bias on one of them could be changed slightly with advantage. It can be seen here that the positive and negative peaks do not have the same shape. The best balance in this respect is shown by amplifier B, which also shows excellent high-frequency performance, with a shorter rise-time than any of the others. Amplifier D suffers slightly from asymmetry. These defects are very minor ones, however, because they could not be picked on listening to the three amplifiers concerned.

So far, no mention has been made of amplifiers F and G. The former shows some very interesting effects. At 30 cycles, the waveform commences with a normal rate of droop, indicating, one would think, adequate low-frequency performance. But before the negative jump occurs, the output current suddenly starts to droop off at a very high rate, as if the primary inductance of the output transformer were suddenly reduced to a very low value. Then, when the negative jump occurs, it is very fast indeed—actually much faster than the original waveform. It is clear that something very odd is happening in this amplifier. A possible explanation for the sudden collapse of the waveform when it should continue its gentle droop is that the power supply does not have sufficient regulation. It is worth noting that at 50 c/sec., this effect was absent, as one might deduce by measuring the 30 cycle waveform. For the over-rapid transition we have no theory, unless both the poor regulation and the excessively fast transition are both due to saturation of the smoothing choke. One would obviously suspect the final electrolytic condenser in the smoothing filter.

At the high-frequency end too, this amplifier is peculiar. The rise rate is quite good—better than that of amplifier A—until, after a short time, the rate falls off seriously. A slight ring is apparent, but it is heavily damped. There is also marked asymmetry. The worst fault, though, is that on the positive peaks of the output waveform, the amplifier is in continuous oscillation at some frequency that is much higher than the frequency range of the amplifier—probably of the order of several megacycles. This can be seen by the fuzziness of the trace at the top of the picture. In the original photograph, the oscillation would be seen quite clearly on the fly-back. It appears that the oscillation starts at the same point at which the rise of the square-wave slows down.

It should be mentioned that this particular amplifier was found on sine-wave testing not to be oscillating at any part of the cycle, at any frequency, and that it produced within 1 db. of its rated output on sine-waves. Altogether a very good example of the limitations of conventional tests.

Amplifier G also had some interesting features. The overshoot is quite bad, and this amplifier would handle approximately 70 per cent. of its maximum sine-wave output voltage on square-wave testing. That is to say, the photographs were taken at a level which with sine-wave input would have given just under half the rated power output. An interesting point about the high-frequency square-wave picture of this amplifier is that the ringing appears to occur at more than one frequency. There is no reason why amplifiers should ring at only one frequency at a time, especially if they have multiple feedback loops. At the level shown, the symmetry was good, but at higher input

levels, both the high and low-frequency square-waves deteriorated badly.

Perhaps the most striking photographs are those of amplifier C. This is a single-ended one, which does not claim high-fidelity performance—perhaps just as well! Severe ringing occurs even with 400 c/sec. input, and the low frequency performance is almost non-existent. The square-wave frequency had to be raised to 1000 c/sec. before the droop disappeared. The high frequency performance is also very poor. The relatively high rate of rise, and very bad ringing are both due to a response which peaks badly at about 30 kc/sec. The result is that to get even as good results as are shown by the photographs, the input had to be reduced until the equivalent sine-wave output was *one-ninth* of the rated power of the amplifier. This example illustrates excellently how a maker can rightfully claim a frequency response that looks very well on paper, but which means less than nothing as far as reproduction quality is concerned, because of poor design in other respects.

## CONCLUSION

The above article does not pretend to be a complete treatise on the subject of square-wave testing. It does serve to show some of the practical results that can be obtained, and how much square-waves will sort the sheep from the goats. With all its advantages, this type of test will still not give an unambiguous answer to the 40-dollar question "Will this amplifier sound well on music?" It will give the experienced worker a pretty good idea of where his designs could be improved, and it seems that the best amplifiers do give very similar square-wave results. Where faults are apparent, the test shows them up much more clearly than any other method, and it will also indicate fault conditions that cannot readily be discovered at all in any other way.

A point well worth noting is brought to light by the results obtained on the two amplifiers tested which were designed in our own laboratory. Both of these amplifiers came out among the best three, and yet when they were designed and built, no square-wave testing had been indulged in. It could be that their good performance is accidental, but of course we prefer to think otherwise. The significant fact is that when investigating an amplifier design with the oscilloscope and sine-wave signals, we have always attached great importance to the behaviour of the amplifier as the input amplitude is wound up *after the overload point has been reached.* Our method has been to ensure that after the overload point, further increase of input signal has no affect other than to produce a nice clean square-wave. This in effect amounts to using the amplifier as its own square-wave generator. It is not considered enough, for instance, if the performance up to the overload point, on a sine-wave is satisfactory, but if overload triggers off an R.F. oscillation, or if on overload, peculiar kinks appear in the squared-off waveform. Nor must the amplifier start motor-boating, however great the input signal may be.

This method of checking apparently produces good results, but the advantage of proper square-wave testing would be that the same results, or better ones would be achieved more quickly. The effects of circuit changes can readily be evaluated with the minimum delay by this means.

# N.Z.A.R.T. NOTES

(Supplied by the Publicity Committee, N.Z.A.R.T., 25 Lees Road, Christchurch, to whom all inquiries should be addressed.)

The 1955 Conference has now joined the legion of Happy Memories and we feel sure that all those who took part in the many and varied functions went away from the "City of the Plains" with the feeling that it had been a weekend long to be remembered The organizing committee can rest assured that their efforts were not in vain and their ability was shown in the way in which all functions ran so smoothly along.

This year the Conference was not overburdened with remits and it was possible to devote more time to general business than in the past. Perhaps the two most important points that came up in this section were requests to the relative authorities that consideration be given to issuing New Zealand amateurs with vehicle number plates bearing the call sign instead of the usual serial number. This is now done in the majority of the States in U.S.A. and gives immediate identification of an amateur in cases of emergency. The other request to be taken up relates to the sale of war surplus equipment that is capable of radiating signals. This is the second time that the Association has made the request that such equipment be withdrawn from general sale and although it may be considered to be a little late, there is still a considerable quantity available which could find its way into the hands of unskilled persons with rather drastic results.

At the end of this year, "Break In" will pass to other hands. The present editorial staff have, on account of personal commitments, found it necessary to terminate their offices. This is a pity as Roy Pottinger, ZL4GP, and his associates have set a standard that will be hard to better. Members showed their appreciation of the present editorial committee's work by the passing of a unanimous vote of thanks at Conference, and the voicing of many glowing tributes. Moves are afoot in Wellington, Auckland, Palmerston North, and Christchurch to set up a Committee to take over as at January next, but to date no definite arrangement has been possible.

The social side of Convention showed that N.Z.A.R.T. has, in its new president, Harry Arnold, ZL3HA, a vocalist of no mean ability. Harry's rendering of an old English ballad not only amazed the visitors, but occasioned much surprise to members of the Christchurch Branch as well. It only goes to show that talent is where you expect it least! Other entertainment was given by that old trouper Strath McKnight, ZL3CH. Strath's humorous monologues were just what was required to break up the natural reserve that always seems to exist at functions of this nature.

Ashburton Branch showed its prominence in VHF equipment when members gave demonstrations with their mobile and fixed portable gear on the Sunday. Four hundred and twenty and 144 megacycle equipment, both crystal and self excited, was on display and communication was made with various locals on both bands as well as with ZL3AR who had his equipment in his car on the Cashmere Hills.

The weekend concluded with Monday's programme of technical demonstrations sponsored by Tricity House, and the usual shack crawl. The technical demonstrations were "Facsimile" by Denis Shipley and "Model Control" by Charlie Dann, ZL3MQ. Both of these showed that there is more in radio than merely knocking the odd receiver together, and that members of the Association have other outlets in the hobby. Those present also saw a film showing the manufacture of "Permali", a laminated plastic. This film was sponsored by E. C. Gough Ltd.

Away from Conference for a few lines The Frequency measuring Contest is now over and entries have reached an all-time high.

Whangarei was treated to an insight into Ham Radio at the "Winter Show". The local branch operated on 80 metres and drew a fair share of public interest.

**BACK NUMBERS OF "R. & E."**

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*Circuits for the Experimenter*

# TRANSISTOR CURRENT AMPLIFIERS

*In case anyone thinks the average experimenter may not have much use for a transistor current amplifier, it should be mentioned that a circuit consisting of one transistor, one variable resistor, one dry cell, and one 0–1 ma. meter can be made equivalent in almost all respects to a 0-50 μamp. meter movement!*

## INTRODUCTION

We doubt whether very many users of multi-range meters would argue in favour of a 1000 ohm-per-volt instrument, as against one with a sensitivity of 20,000 ohms per volt. The advantages of a sensitive movement are so well appreciated these days that most manufacturers of commercial multi-range instruments turn out at least one model which uses a –50 μ amp. movement. In spite of this, the more robust 0–1 ma. movement is much to be preferred for all measurements in which the additional sensitivity is essential. Even 20,000 ohms per volt is not sensitive enough for many purposes, so that we are forced to use vacuumtube voltmeters, with their attendant disadvantages. Thus it is that any scheme whereby the sensitivity of a meter can be greatly increased is likely to prove exceedingly important and useful. Also, this is one of the applications that were just waiting for the advent of the transistor, whose characteristics are more suited to it than are those of any thermionic valve. Just so that we may realize the transistor's advantages to the full, let us enumerate the features of a 0–50 μ amp. meter, made from a 0–1 ma. movement by using a transistor amplifier.

## TRANSISTOR ADVANTAGES

(1) The transistor amplifier, as compared with a valve amplifier is very simple, and contains very few parts to go wrong.

(2) The transistor is fundamentally more suited as a current amplifier than the valve, and a single transistor stage can provide a current gain of 40 or more, while retaining the low input resistance of the meter movement itself. This means that the input terminals of the amplifier circuit can be used in every way as if they were those of an actual meter movement having the sensitivity of the movement actually used, multiplied by the current gain of the amplifier circuit. Indeed, were the meter to be re-scaled, and placed in a case with the amplifier circuit, the behaviour is such that one would not know that the amplifier were present.

(3) In common with valve-operated meter circuits, the robustness of the relatively insensitive meter movement is retained, and its operation is more reliable than that of a much more sensitive movement. This question of reliability is one which does not always occur to meter users. The more sensitive the movement must be, the smaller the restoring force that must be supplied by the coil springs that are part of the movement. Thus, dust, and other disturbing influences, cause more trouble from "sticking", and general unreliability than they are able to do in the case of the insensitive movement. Under the heading of "other disturbing influences" comes such mechanical faults as minute imperfections of the

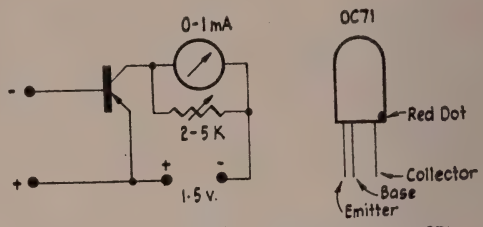


Fig. 1 Connections for OC71

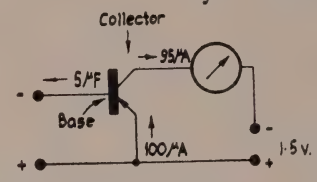


Fig. 2

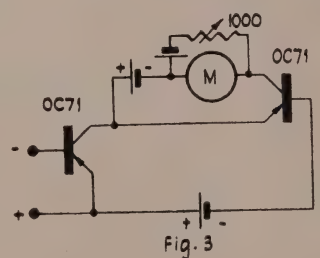


Fig. 3

jewelled bearings, and damage to them or to the needle bearings that carry the moving coil.

(4) In general, less sensitive meter movements are much more "dead beat" than sensitive ones. This is because the latter have coils with more turns of finer wire, and therefore of higher resistance. Thus, the electrical damping which causes the meter to come to rest quickly after a current has been applied, is less with a sensitive movement. The worst damped movements of all are those belonging to laboratory galvanometers, which sometimes swing for several seconds before coming to rest. This not only makes their use exceedingly time-consuming, but makes them more susceptible to damage when accidentally overloaded.

(5) As compared with a valve amplifier, the transistor amplifier power supply is so small as to be insignificant. A single pen-cell is adequate for many months' use as the primary supply for a single-stage transistor amplifier. The current drawn from the cell can never exceed the full-scale current of the meter movement used, while the idling current, which flows

when the meter is not being used, is only a few micro-amperes. Indeed it is so small that one could quite reasonably omit a switch, and leave the circuit running all the time, without sensibly affecting the life of the battery or cell used.

## DISADVANTAGES

After an impressive list of advantages like the above, it would be surprising if there were no compensating disadvantages. These do exist, and for some purposes, they rather limit the usefulness of the transistor amplifier—at least in the simple form in which it is used here.

The main disadvantage is the temperature-sensitive nature of the transistor itself. To observe this, it is only necessary to place the hand round the transistor while the meter is reading. Before many seconds have passed, it will be seen that the current has increased quite markedly. It returns to its original value after the source of warmth has been removed, however. This temperature effect is quite serious if it is hoped to take accurate current readings with the amplifier-meter arrangement, because normal variations in room temperature, such as occur all the time will be quite noticeable. Moreover, the more sensitive the amplifier, the greater will this effect be. It can be reduced somewhat by such expedients as mounting the transistor in a fitting hole in a block of copper or other heat-conducting material. The most that this can do however, is to slow down the temperature changes as they take place, so that the transistor is not affected at all by changes which last for such a short time that the mass of the metal in which the transistor is mounted is not able to follow them.

A better solution is to use balanced circuits, like the well-known balanced valve voltmeter circuits, so that the temperature effect on one transistor is cancelled out by the effect of the same temperature change on the other. However, this is more expensive, as it uses two transistors per amplifier stage, and in any event, temperature effects may be ignored if highly accurate measurements are not needed.

The only other disadvantage is that there is noticeable non-linearity of the scale at low currents. That is to say, below about a tenth of full-scale deflection. However, this non-linearity is less than that generally found with valve voltmeters, and may also be disregarded except where high accuracy is needed. From a tenth F.S.D. to F.S.D. itself, one can take the scale readings as true, with reasonably small error.

## CIRCUIT DIAGRAM

A glance at Fig. 1 shows immediately how delightfully simple the amplifier is. So simple is the circuit that one might be forgiven for thinking that some parts of it had got left out! Not so, however. The transistor is used in what is known as the grounded emitter circuit. That is to say, the *emitter,* which is signified in symbol for the transistor by the arrow-headed line, is common to both input and output circuits, just as the cathode is in a conventional valve amplifier. The input is applied between the *base* and the emitter, the base being the thick line. In the OC71, which is technically described as a p-n-p junction transistor, the emitter must be made positive in potential with respect to the base for current to flow in the input circuit. Thus, the base acts as the negative input terminal, and the emitter as the positive one. In a p-n-p transistor (whether point-contact or junction) the third electrode, the *collector,* is made negative with respect to the base. Now this is the non-conducting direction for the germanium diode made up by the base and collector electrodes, but the action of the transistor is such that current in the emitter circuit allows current to flow in the collector circuit, and this is the amplifying property upon which the device is based.

An important property of the transistor is its current gain. This corresponds in some ways to the amplification factor of a triode. The latter is always indicated by the Greek letter $\mu$, (often written "mu" to make it easier for printers) and the current gain from emitter to collector circuit of a transistor is always called by the Greek letter $\alpha$. Junction transistors always have an $\alpha$ which is slightly less than unity, so that at first sight it might seem impossible to obtain any current amplification at all. Fig. 2 may help to elucidate matters a little. Let us imagine that in this circuit we have an emitter current of 100 microamps flowing. In order for this current to flow, the circuit from base to emitter must be completed in some way, so we have drawn a resistor there, to complete the D.C. path. Now suppose that the transistor has an $\alpha$ of 0.95. This means that the collector must at all times draw a current $0.95\, i_e$. We have already assumed the conditions to be such that $i_e = 100\ \mu$amps, so that, the collector current must be 95 $\mu$amps. Remembering that the emitter current flows *away from* it, the currents in the circuit must be as indicated by the arrows in direction. and they must have the magnitudes marked against the arrows. Thus there must be a current in the base lead of 5 $\mu$ amps.

Now if the base current changes, the transistor, being a linear device will change its other electrode currents in proportion. The base current in our amplifier arrangement is the current we are measuring, so let us suppose that it rises to 10 $\mu$ amps. The emitter will then draw 200 $\mu$ amps and the collector 190 $\mu$amps. Thus, an input current change of 5 units has caused an output current change of 95 units. This is an amplification of 95/5, or 19 times. In practice, many transistors have much greater amplifications in the grounded-emitter circuit than this, and the rated amplification for the OC71 in this circuit is 47 times. This explains how it is that the circuit will change a 0–1 milliammeter into a 0–50 microammeter! Just as valves do not always have the exact "bogey" characteristics given in the data books, so too do transistors' characteristics vary about the average. At one time, one of the major difficulties in applying them was that their variability was considerably greater than that of valves, but with some types this is no longer the case, and the published curves and data can be relied upon for design purposes just as valve data can. For the purpose of regulating the sensitivity of the circuit, a variable resistor is included. This has been shown in shunt with the meter, but it can also be used in series with it. In practice, a known current of 50 amps. is passed through the input circuit, and the resistor is adjusted until the meter reads full scale. If desired, the sensitivity can readily be reduced by shunting the input terminals, or by decreasing the value of the resistor in shunt with the meter. In this way, the amplifier can be made to have an overall gain of, say, ten times, turning the 1 ma. meter into a

(Concluded on page 53.)

# The PHILIPS Experimenter

An advertisement of Philips Electrical Industries of N.Z., Ltd.

## No. 94: A Transmitter-Receiver for the 160-Metre Band—Part 2

### THE TRANSMITTER—Continued

### FERROXCUBE COIL CORES

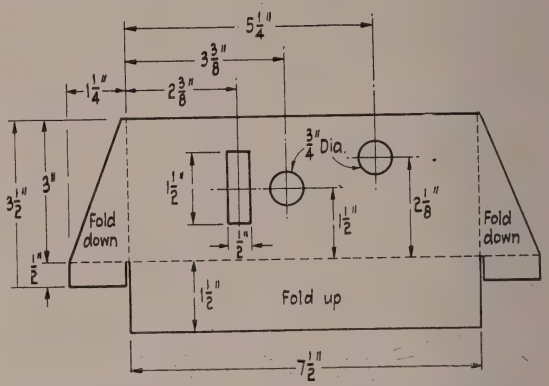
An innovation in the transmitter is the use of Ferroxcube as a core material for the coils. Hitherto, Ferroxcube has been recommended only for aerials of portable broadcast receivers, but there is no reason at all why it should not be used in transmitting circuits where its advantages are applicable. In the first place, it greatly reduces the labour of coil winding for the frequency we are interested in at the moment. As can be seen from the photographs, only a very few turns of relatively heavy wire are used, making the coils as easy to wind as short-wave coils. Had Ferroxcube cores not been used, it would have been necessary to use formers at least one and a half inches in diameter, with windings of over 80 turns of something thinner than 30-gauge wire. And if the Q of the coils were to be as high as is obtained with the Ferroxcube cores, it would almost certainly be necessary to use Litz wire, together with wave-winding, as is used in I.F. transformers. This sort of winding is virtually impossible to make unless one has a wave-winding machine, so that from the constructional point of view, the cored coil wins hands down. No difficulty will be experienced from temperature effects causing frequency drift, because the cores are not closed ones. Most of the magnetic circuit is air, so that the temperature co-efficient of the core material has an unmeasurable effect on the inductance.

If the cores had not been used, it would have been quite impossible to get the transmitter into such a small space, so that portability is greatly improved thereby.

### COIL DATA

The coils are wound on half an inch diameter bakelized paper former. This has the advantage that Ferroxcube aerial rod, as sold for portable receivers, is a neat fit inside it. Some samples will be found on the tight side, but it is an easy matter to loosen things up by attacking the inside of the former with a rat-tailed file until the core is a push fit. Since nothing is used to keep the cores in place, it is necessary to make sure that they really are tight enough, without being impossible to remove them when necessary.

The oscillator coil consists of 16 turns of 26 s.w.g. enamelled wire, close-wound, and tapped at the centre for the H.T. connection. For this coil, a piece of Ferroxcube aerial rod 2 in. long is used, and is pushed into place into the former after the coil has been wound, so that the coil is exactly central with respect to the rod. The winding is terminated by rivetting solder lugs near each end, and wrapping the wire



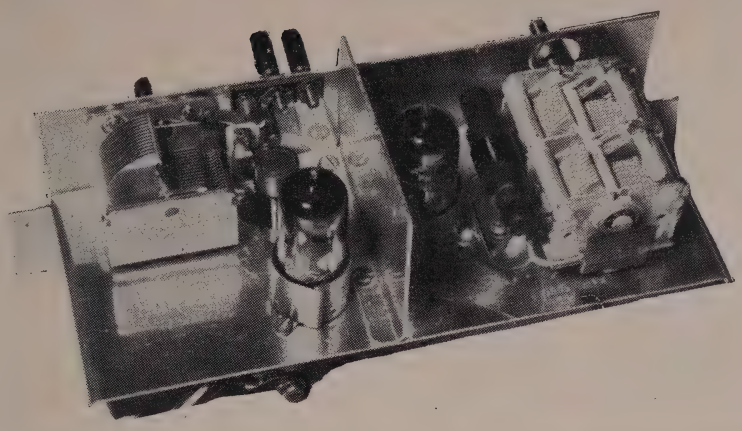

*Working drawing for the transmitter chassis, which measures only 7½in. x 3in. This is a top view.*

twice round the lugs, and then soldering. The centre tap is brought out by winding on half the coil turns, making a twist in the wire, and then continuing the winding to the end. After the ends have been soldered in place, the twist is put in firmly with a pair of long-nosed pliers, and the two wires comprising it are soldered together, making a solid pig-tail about a quarter of an inch long.

The aerial winding uses a core only 1¾ in. long, which in this case goes completely inside the coil former. The winding is also of 26 s.w.g. enamelled wire, and comprises 24 turns, also close-wound.

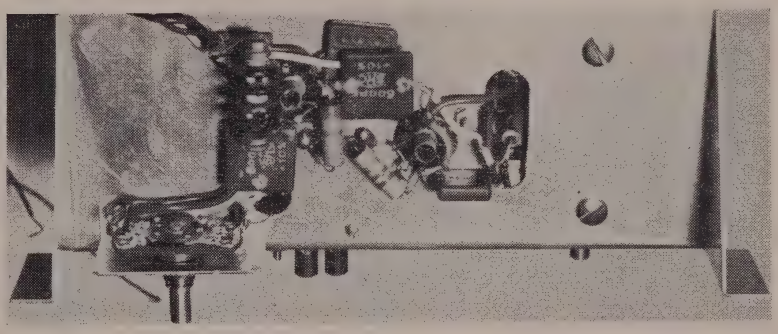
### CONSTRUCTION

The transmitter is built on a chassis measuring only 3 in. x 7½ in., but in spite of this, there is plenty of room, and no over-crowding of parts. The chassis is made in such a way that it can be screwed to a panel without having to partially dis-assemble the works, provided that the requisite holes have been made in the panel to start off with. The shafts of the tuning condensers, are extended through a vertical fold in the chassis, by means of which the latter is screwed to the panel. Bracing brackets are built into the chassis, with turned-out flanges which are also screwed to the panel when this is put on. The idea of this form of construction is to allow of two separate forms of construction for the completed station. The receiver and modulator chassis will also be made of approximately the same dimensions, so that they too can be mounted on the front panel. The panel, with the three chassis attached (or two, if the station is built for CW only) is then merely screwed



*Left.—Top view showing the oscillator valve and tuning condenser at the right, and the P.A. valve, and output tank parts on the left.*

*Below.—Under-chassis view of the transmitter, with the front of the chassis showing at the bottom of the picture. Note the slot at the right giving access to the tuned circuit, which is above the chassis.*



to a containing box of wood or metal. If desired, this box can be just deep enough to accommodate the deepest chassis, thus making a very compact unit, but with batteries externally carried. Alternatively, the box can be made deeper, so that space is left behind the chassis to accommodate the batteries. This would perhaps be the best plan if the utmost in portability is desired, while the first scheme can be used if two small packages are considered preferable to one somewhat larger and heavier.

A baffle shield is placed between the two stages of the transmitter above the chassis, but none is required underneath. This shield was put there for stability reasons—not the sort of stability that is concerned with self-oscillation, because even without it there was no trouble of this sort, but because without it, it was found that the tuning of the final was able to pull the oscillator frequency quite a long way. In practice it was only about five kilocycles per second, but with a band only 25 kc/sec. wide, this was too much. With the shield in place, this pulling disappeared almost entirely. If the oscillator was set to zero beat with the heterodyne wavemeter, with the final tuning condenser at minimum capacity, and the latter was then tuned through resonance to maximum capacity, the frequency change was no more than a few cycles per second, as evinced by a beat frequency that did not rise above a low "growl". The shield also had a good effect on the keying stability, the chirp being negligible after the shield had been installed. For this test, both oscillator and P.A. stage were keyed.

In the oscillator compartment, the only components above the chassis are the coil and its tuning condensers. One of the fixed 500 mmfd. condensers can be seen connected between the back end wiper of the two-gang condenser, and the stator lug nearest the valve. The other 500 mmfd. unit is in an exactly similar position at the other end of the gang.

The oscillator coil is mounted simply by soldering the end lugs of the coil directly to the stator lugs of the gang condenser. A rectangular hole is made in the chassis between the oscillator valve and the gang condenser, and through this are taken the leads from each end of the tuned circuit. This slot is made half an inch wide, and the 2.2k. decoupling resistor is suspended from the centre-tap on the coil, the other end being terminated on an insulated solder tag mounted directly underneath. This can be seen in the under-chassis view.

At the P.A. end of the chassis, we have the valve, mounted somewhat towards the back of the chassis, so that the pi-section output filter can be mounted in front of it. The output condenser is the midget variable .500 mmfd. which is seen at the extreme left in the photograph. Next to it, and attached to the front bend in the chassis, is the 500 mmfd. adjustable condenser at the input end of the pi-section filter. This is a conventional compression-type padder condenser, and has to be adjusted with a screw-driver. However, this is little of a disadvantage, as it needs adjusting only when the set is used with a different aerial, or in a different location. Tuning, as against matching, is carried out with the variable, so that frequency changes within the band, once set up on a given aerial, will not necessitate re-matching, and therefore use of the pre-set condenser.

The coil of the pi-coupler is mounted vertically, one end being fixed to the stator lug of the variable condenser, and the other being attached to the lug belonging to the aerial terminal, to which one side of the pre-set condenser is also fixed. The two points marked "x" on the diagram in last month's instalment represent a pair of terminals, brought out to the front panel. The upper one is at once the

(Continued on next page.)

aerial terminal, and a terminal for adding a fixed condenser in parallel with the pre-set. The earth terminal does a similar double duty. By this means, it is a simple matter to adjust the value of the output condenser to any value from a few mmfd. up to 0.001 mfd. or even higher. This can be done by having available fixed condensers of 500, 1000, 1500 mmfd., etc., so that if with the aerial in use, a greater capacity than 500 mmfd. is wanted in order to obtain proper matching, the additional fixed capacity can be clipped in parallel with the aerial-earth leads. This simple arrangement obviates the need for a tap switch, which would have taken up too much room, although it would certainly have been more convenient in operation.

Under the chassis, on a small bracket, is the Send/Receive switch. It is a two-pole change-over affair, and the use to which one pole is put was shown on the circuit diagram in last month's issue. The second pole will be used to turn on and off the filaments of the transmitter and receiver. With filament type tubes, it is entirely practical to do this and eliminate an H.T. switch, on account of the quick heating of the valves. The arrangement makes the S/R switching as uncomplicated as it could possibly be. The filament side of the switch is at the left in the under-chassis photograph, and the 500 mmfd. mica plate blocking condenser can be seen going straight from the plate pin on the final amplifier to the switch. Simple point-to-point wiring is the order of the day under the chassis, and only two tie-points have to be provided. One of these has already been mentioned, while the other can be seen at the left-hand back of the chassis. It is used to terminate the H.T. + 135v. lead, and the final's plate choke. The other tie-point can be seen to the right of the oscillator tube, terminating the H.T. 67½v. lead, and the decoupling resistor of the oscillator.

(To be continued)

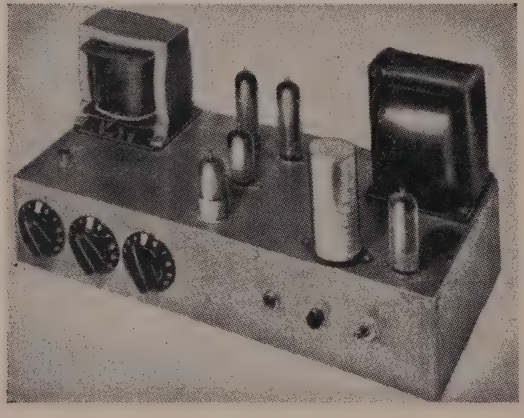
# MARCONI TELEVISION CENTRE

Throughout Britain the advent of Commercial Television has posed serious problems to many organizations interested in the television medium. To all such, the Marconi Television Centre, established by the Broadcasting Division of Marconi's Wireless Telegraph Co. Ltd. near the heart of London, and the first fully-equipped television training studio of its type in Britain, is available to any organization wishing to use the equipment for training its own studio and production staffs.

It can be used by any organization, large or small, for rehearsals or auditions under true operational conditions. Telecine equipment is available for those wishing to appraise filmed programmes on television. A complete mobile Outside Broadcasting Unit is attached to the Centre and can be used to gain experience in "O.B.'s", and for the production of recorded "O.B." programmes.

## *Further Notes on the*

# Mullard 5/10 High-Quality Amplifier



When an American magazine such as "Radio and Television News", in its March, 1955, issue, says: "The best amplifier circuit produced in England for several years", and then goes on to devote four pages to its qualities and design, then surely this is praise indeed. The Mullard 5/10 amplifier has been enthusiastically received by all leading trade journals as the most outstanding and easily produced high quality amplifier yet produced.

The quality of reproduction from this amplifier is such as to satisfy the most fastidious of musical critics, while the clever design of the tone control system enables the user to separately and independently set the bass and treble controls to any desired position in order to compensate for record or room characteristics. In this respect the treble control is variable from + 10 DB. to —10 DB. at 10,000 cycles, and the bass control is also continuously variable from + 11 DB. to —5 DB. at 20 cycles. In the circuit diagram reproduced on page 33 of the July, 1955 number of "Radio and Electrical Review", the main amplifier consists of three conventional valve stages with 26 DB. of negative feedback taken from the secondary of the output transformer to the cathode of the first valve and utilizes four noval-based audio valves and a rectifier. The high basic sensitivity makes it possible to use a wide range R.C. tone control network while retaining enough gain to fully drive the amplifier from any crystal pick-up giving a relatively high output voltage without using a separate valve pre-amplifier.

Full details for constructing this new and economical Mullard amplifier circuit are given in an eighty-six page booklet entitled "Mullard 5-Valve High Quality Amplifier Circuit" priced at 3s. 6d., which can be obtained from most dealers or direct from the New Zealand Distributors of Mullard Overseas Ltd., Messrs. C. & A. Odlin Timber & Hardware Co. Ltd., Wellington.—P.B.A.

*The Editor's Opinion*

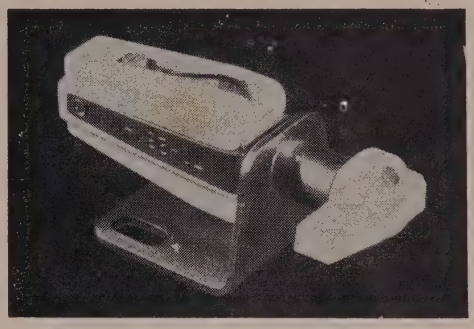
# THE RONETTE TYPE PX PICK-UP CARTRIDGE

It is some time now (November, 1953, to be precise) since we were able to announce in these pages the advent of the Ronette 284 series of pick-up heads. Since that time, the excellent opinion we formed of their characteristics and capabilities has been amply confirmed. We have ourselves used many examples of the 284-P head, and have found them comparable in almost all respects with other high-quality pick-ups on the market—some of them at very much higher prices.

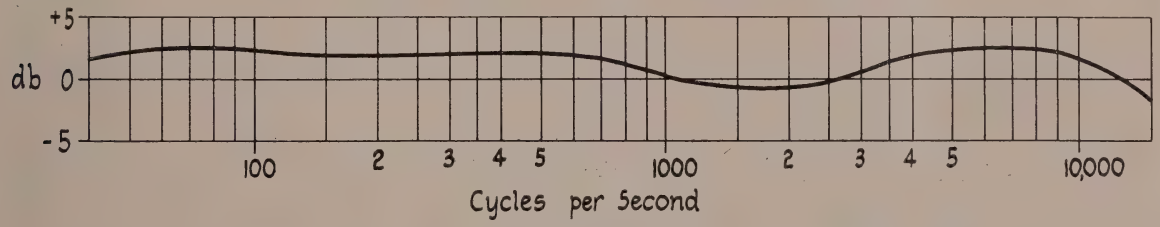
## PREJUDICE AGAINST CRYSTALS

There still appears to exist an unwarranted prejudice against crystal pick-ups, for no other reason than that they ARE crystals. This is undoubtedly due to two things. First, it is only in the last few years that high-quality pick-ups of this type have been produced. Before that time the only pick-ups that could justifiably claim the term "high quality" were magnetic ones, and the crystals of the day were not only cheap, but, relatively speaking, nasty as well. The criticisms that could with all justification be applied to old fashioned crystal units are no longer valid when applied to the type of crystal pick-up of which the Ronette is an excellent example. Their response is as smooth, and their tracing ability every bit as good as most magnetic pick-ups, and definitely superior to some that claim to be high-fidelity articles. No longer do they suffer from irregularities in the response curve which gave them what many people stigmatized as "that crystal sound". Moreover, they are just as easy to compensate as are magnetic types, and with the proper equalization give results which are indistinguishable from those of high-quality magnetics.

We might mention at this point that at the recent demonstrations of high-quality audio reproduction given by this journal, we demonstrated that the same record, played through the same amplifier and speaker system, but with different pick-ups, sounded identical whatever type of pick-up was used, provided both were excellent in their class.



For all normal purposes, it can be said that a high-frequency response of this sort is eminently satisfactory, but the fact remains that modern records are often made with a frequency response which extends to 15,000 c/sec. or higher. As a result, many high-fidelity fans will be pleased to hear that the makers have just put into quantity production a new cartridge which has identical characteristics with the type P in all other respects, but whose high-frequency response is said to extend to 17,000 c/sec. We were fortunate in having one of the first of these to come into this country given to us for testing, and we can say that it comes well up to the high expectations based on the performance of the type P cartridge. The only visible difference between the P and the PX, as the new unit is called, is that the cantilever of the microgroove stylus has been lightened by a line of holes between the mounting screw and the stylus, but the fact that there is a difference is vouched for by the response curve. This was taken using a Decca frequency disc LXT2659.




## THE NEW TYPE PX CARTRIDGE

The response curve of the now well-known Ronette 284-P cartridge, when loaded with a resistor of some 120,000 ohms, is sensibly flat on a constant-velocity basis, which means that the same kind of record compensation can be employed that is used for magnetic pick-ups. This is a great advantage where pick-ups are to be compared directly, since no special circuits need be provided for the crystal pick-up. Apart from this, the most noticeable feature of the 284-P unit is that the upper frequency range ends quite suddenly at between 11,000 and 12,000 cycles per second.

Incidentally, it should be noted that this curve was taken with a 1-megohm load across the pick-up and with no equalizing circuits of any sort. This emphasizes the fact that the Ronette is an almost perfect constant-amplitude device, because the recording characteristic of this particular disc is such that, if played by a pick-up which has a constant-amplitude response, the overall result should be a level output response. In other words, a constant amplitude device is automatically self-correcting for the response curve of L/P records. From the curve, it can be seen that the response, taken in this way, is level within plus and minus 2½ db. from 40 to 15,000 c/sec. It will also be seen that the very gradual deparature from exact flatness which starts at about 700 c/sec. and crosses

(Concluded on page 51.)

# DIVIDING NETWORKS FOR LOUDSPEAKERS—Part 1

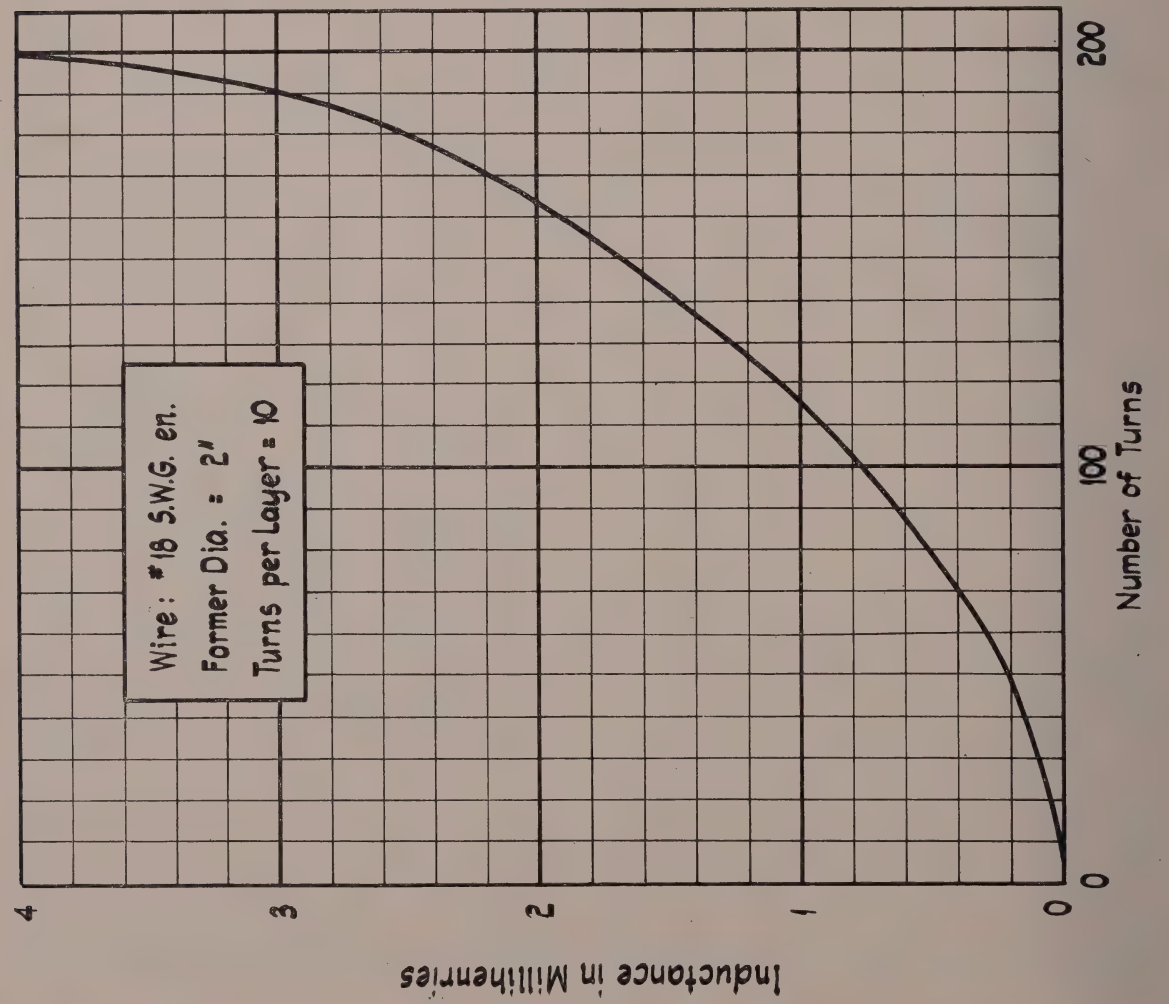
## WINDING OF AIR-CORED INDUCTORS

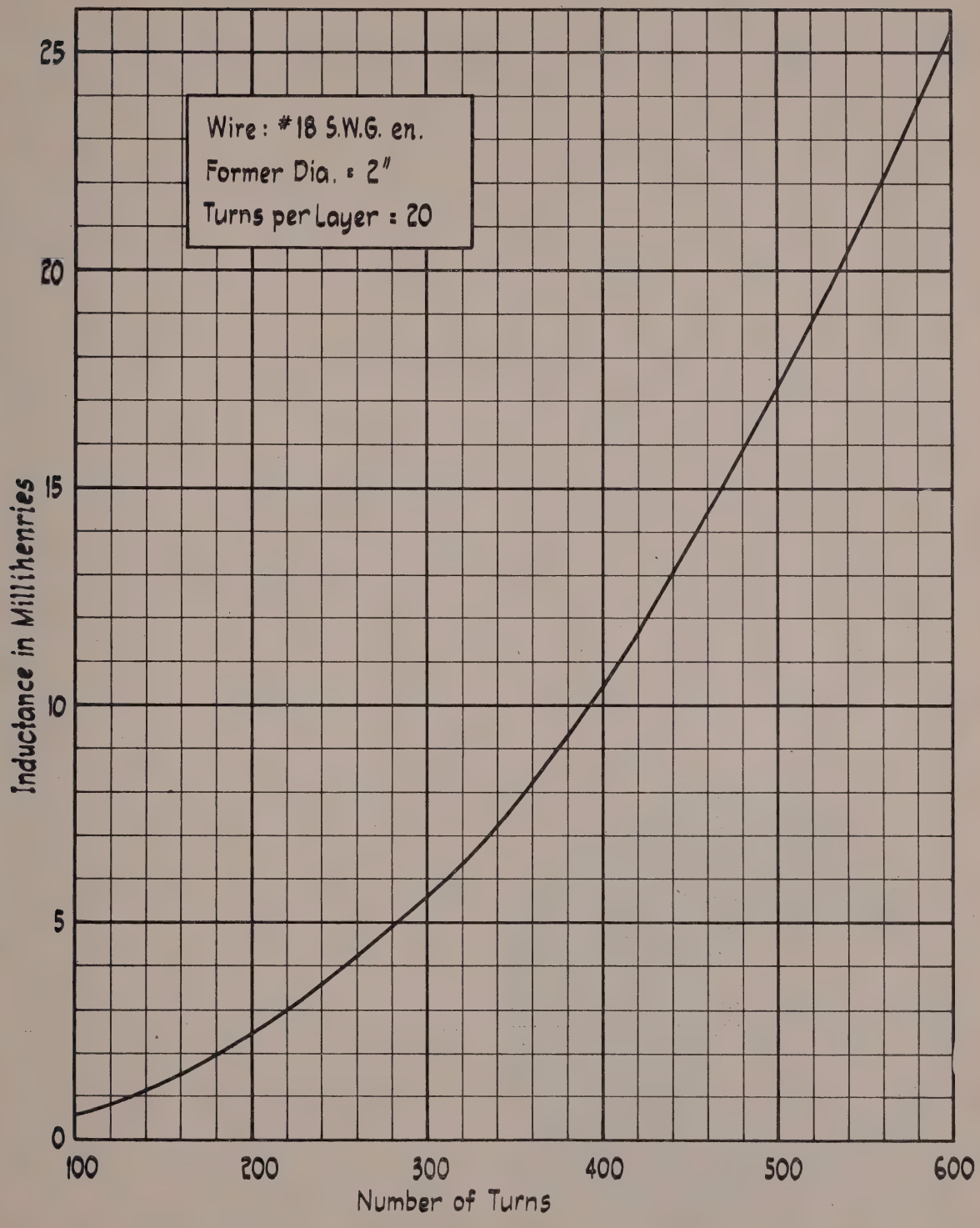
Whatever the speaker impedances, and cross-over frequency that are to be used in a dividing network, it is necessary to wind air-cored inductors to specified values of inductance. This first instalment of the present article presents two curves from which the correct number of turns can be found, for winding any inductor up to 25 millihenries. This range is adequate to cover all speaker impedances from 0 to 100 ohms, and all cross-over frequencies between 400 and 4000 c/sec.

Two curves are given because the one which provides for inductances up to 25 millihenries is not satisfactory to read for values below about 3 millihenries. At the same time, for the lower values of inductance, it is better to change the winding form. The curves are applicable only to the forms of winding specified on them. In both cases, layer winding is to be used with the wire and number of turns per layer as specified on the curves. In all cases, the coils come out to manageable proportions, and if strips of tape or thread are inserted between the former and the first layer of wire, these can be tied tightly over the winding when it is finished, and the coil made solid with polystyrene dope. The former can then be cut away, giving a self-supporting coil.

## SUBSEQUENT DATA

In Part 2 of this article, appearing next month, we will present a series of curves from which with only a pencil and ruler, the inductance needed for any speaker impedance and any cross-over frequency can be read off in a matter of seconds, without any calculation at all. Part 3 will give a similar series of curves enabling the necessary capacity to be found to complete the network.




Wire : #18 S.W.G. en.
Former Dia. = 2"
Turns per Layer = 20
Inductance in Millihenries
0
5
10
15
20
25
100
200
300
400
500
600
Number of Turns

*Test Equipment*

# DIRECT-READING IMPEDANCE COMPARATOR—Pt. 2

## PROTECTIVE DIODE CIRCUIT

In the first instalment of this article, mention was made of the rather complicated-looking circuit of four diodes, which are arrayed round the grid circuits of the 6SN7 voltmeter circuit. These diodes are not essential to the measuring arrangement, and are present only to prevent the pointer from being swung hard against either stop in the event that the test terminals are either open or short-circuited. From Fig. 1 it can be seen that if either of these things occur, the full bridge voltage is applied to the amplifier and rectifier circuit, and the result would be a reading that is far off the meter scale. Since both 6SN7 grids have potentials applied to them, it is necessary to prevent either grid from swinging past the limits of potential that represent full-scale deflection in either direction. Moreover, since each grid is able to move in either direction, the protective circuit must impose two limits on each grid. For this reason, four "catching" diodes are used, two to each grid.

To see how these function, let us take our hypothetical case once more, in which the meter is scaled to read zero at the centre, —10% at the left-hand end of the scale, and + 10% at the other end. Our previous calculations showed that for this scaling, the grid of each half of the 6SN7 has to accept a signal equal to half the bridge voltage multiplied by ten—the amplification of the circuit between the terminals and the rectifier. This amounts to 10 volts, so that the grids are both at potential of —10v. when the bridge is balanced. If the reading is to be —10%, the potential applied to one diode is reduced to almost 9.5v., while that applied to the other rises to almost 10.5v. Thus, we have changes of approximately 0.5v. at each grid, producing full-scale deflection. In the main circuit diagram, the left-hand half of the 6SN7 obtains its signal voltage from across the unknown, so that if the pointer is reading —10%, this grid will have its potential changed to —9.5v. If the unknown should be farther from the standard than —10%, the pointer will tend to be driven off the scale. If we can prevent the left-hand grid from going more positive than —9.5v., and at the same time, prevent the other grid from going more negative than 10.5v., the pointer will not move farther than the end of the scale, however great the departure of the unknown from the standard. Thus, at each end of the scale, two of the diodes come into action. For the end we have been discussing, the ones concerned are those with their plate to the left-hand 6SN7 grid, and cathode to the right-hand 6SN7 grid respectively. From the negative side of the power supply, we have a voltage divider for each catching diode. The cathode of the extreme left-hand diode is held at —9.5v. by the adjustment of the potentiometer. Now this diode is not normally conducting, because in the absence of a reading on the meter, the plate, which is directly connected to the 6SN7 grid, is at —10v., and therefore negative with respect to its cathode. But as soon as full-scale reading is reached, the diode conducts, connecting the 6SN7 grid to the tap on the voltage divider. Thereafter, the rectifier diode can produce as much voltage as it pleases, but it is unable to drive the 6SN7 grid more negative. The action of all four diodes is similar, and they establish limits of potential outside which the 6SN7 grids are unable to go. Unfortunately, there is no very sharp point at which a diode conducts, so that the "catching" effect is not as sudden as we could wish. However, the system does work, and provides a cushioning effect that prevents the pointer from hitting either stop hard, even though it cannot prevent it from reaching there. In the original instrument, the limiting action of the diodes prevented the circuit from presenting the meter with more than enough current to deflect the pointer 100 μamps. off scale at either end. There is thus no possibility of meter damage whatever happens. It would, of course, be possible to provide the meter with a normally-off push-to-read switch, and this would prevent the meter from reading at all while the unknown was being inserted or taken out of the test jig, but such an arrangement would not prevent a faulty component from banging the meter hard against the stop. At the same time, it would drastically slow down the process of taking a reading. Where the instrument is not in continuous use for testing components off a production line, it might be possible to put up with this loss of time.

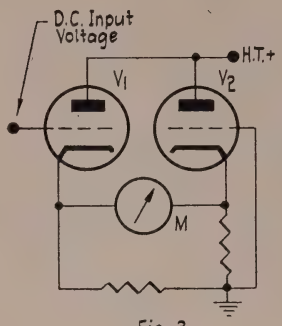


Fig. 2

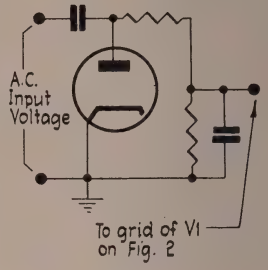


Fig. 3

The diode circuits are set up as follows: A "standard" resistor, of any convenient value and tolerance is placed in the "$Z_s$" terminals, and a potentiometer is connected to the other pair, after the circuit has been zero-adjusted. The potentiometer is adjusted to give full-scale reading, or the outer limit reading, whichever is most convenient. (Incidentally it is best to have the outer limit mark somewhat in from full-scale). Then the appropriate diodes are adjusted with their potentiometers until the setting of the latter just fails to affect the reading. The best way of ensuring this is to remove both diodes while the reading is set up. Then the diodes are replaced, and the potentiometer settings found individually. They should be adjusted so that pulling them out makes, say, a pointer's width difference to the reading, but no more. The same procedure is then gone through for the other end of the scale, and the diodes associated with it.

## CALIBRATION

When such an instrument as this is in use, it must from time to time be checked to ensure that its

calibration still holds. The first essential is to see that the meter movement itself is properly set to zero. The scale zero will normally be at the centre of the scale, and the pointer will not read scale zero unless the instrument is on and working. This zero is also affected by the sensitivity of the circuit, so that should this change through ageing of valves, or for any other reason, it will be necessary to re-set it. For this reason, a zero-set control is brought out to the panel. It is the 10k. balancing potentiometer in the plates of the 6SN7. When the instrument is working, both rectifiers, and both 6SN7 grid circuits have signal applied to them, and these signals pass through the amplifier before reaching the meter circuit, so that should there be any inequality between the gains of the two channels, this will also affect the zero reading. Thus it is necessary to set the zero with the whole bridge circuit working, and not with just the 6SN7 going, and with the bridge unexcited. Therefore, a calibrating switch should be provided in any finished instrument, which connects equal resistors to the $Z_s$ and $Z_x$ terminals. If these resistors are accurately equal, slight inequalities in either side of the measuring circuit do not matter, because the pointer can now be adjusted to the scale zero with the certain knowledge that it can come to this position only when the unknown equals the standard.

It is also desirable to have a second calibration position in which one of the indicated limits is set up at the bridge input terminals. This can be done by having two resistors built in on the calibrate switch, of such value that they give + 10%, or whatever the desired limit is. With the calibrate switch in this position, we know that the meter should read at the calculated point on the scale. If for any reason the sensitivity of the measuring circuit has changed from the last time it was calibrated, the reading will not be correct, and some means must be provided for correcting it. This is the resistor R shown in series with the meter movement. It is there as a sensitivity control, and it determines how much pointer movement a given voltage difference at the 6SN7 grid produces. Unfortunately its use will also affect the zero setting, but this does not matter very much. The procedure is to set the zero, using the panel control, switch to the "Cal. + 10%" position, and set the pointer with the meter series resistor R. Then switch back to the "Zero set" position, and see if the zero has changed. If it has, correct with the zero set control, and then go back to the "Cal.+10%" position, and re-check. One or two movements backwards and forwards between these two controls will see the pointer correcting set on both marks. It is then ready for use.

## OMISSIONS IN PART 1

Unfortunately, two small diagrams were left out of Part 1 of this article, which appeared in last month's issue of "Radio and Electrical Review". These have been printed here, and should make the script somewhat clearer than it was without them.

## USES OF THE COMPARATOR

The applications for a comparator such as this are legion. It can be used for sorting almost anything, from R.F. and oscillator coils, to resistors and electrolytic condensers. If it is built for a specific purpose, it is an advantage to build in the standards that are to be used, and at the same time to provide "open bridge" terminals, as shown on the circuit diagram, so that any external standard can be used if needed. The instrument illustrated was designed for use only at 50 c/sec., but there is no reason why higher audio frequencies should not be used for purposes for which 50 c/sec., is unsatisfactory. For instance, for testing small speaker transformers, a higher frequency would be advisable. It would only be necessary to feed the bridge from a suitable oscillator instead of from the mains. For R.F. coils, the same principle exactly can be used, but the construction and detailed design would have to be altered in order to allow a fairly high test frequency to be used. For the broadcast band, a frequency of the order of 100 kc/sec. would be satisfactory, while for most short-wave coils, 1 mc/sec. would be high enough. For testing most capacities, 50 cycles would be adequate, but for the smaller values, below 200 mmfd., a higher frequency would be advantageous.

One interesting point is that since the bridge measures impedance, it does not separate the resistive from the reactive component, and thus will not tell directly whether a condenser is leaky, for example. It will only give a reading indicative of the impedance of the component tested. Because of this limitation, however, it is possible to use resistors as standards for measuring capacitors or inductors. For instance, for testing a batch of 1 mfd. condensers, $Z_s$ should be equal to the reactance of 1 mfd. at 50 c/sec. This is 3180 ohms, and as far as the bridge is concerned, it cannot tell whether this is an actual resistor of this value, or whether it is a condenser having this reactance. In either case the result is the same. Thus, the bridge can be used for matching purposes, with $Z_x$ and $Z_s$ of the same kind, or it can be used with resistors as the standard for any kind of impedance whatever. The instrument is thus very versatile, and of great utility, especially in factories, or other places where large numbers of components have to be tested.

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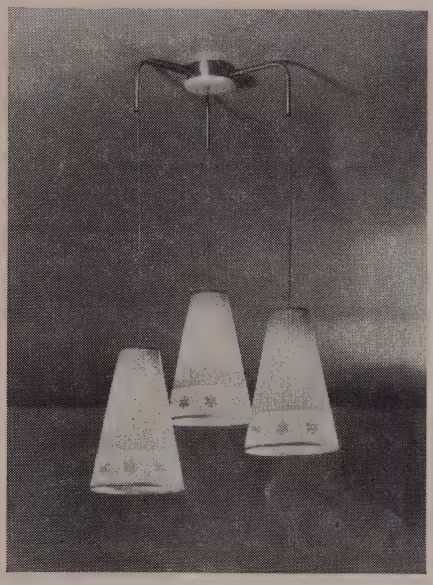
# ELECTRICAL AND TRADE SECTION

## CONTEMPORARY DESIGN IN LAMP FITTINGS

F32091.—Single-arm bracket to match fitting F34048. For 2-40W. Osram lamps.



F34042.—Suspension for three 60W. Orsam lamps. Satin brass metalwork with white relief. Cherry red shades.

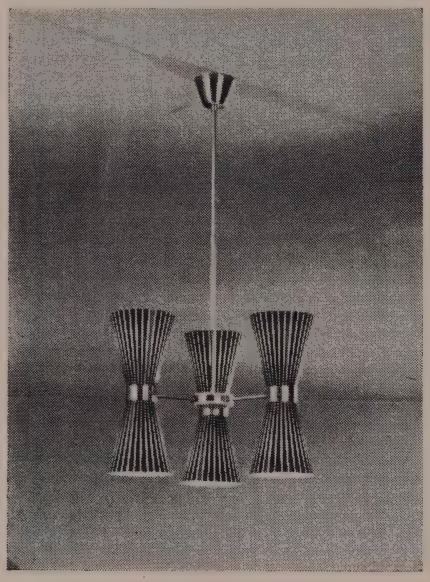
F40100.—Pendant for 200W. Osram lamps. Satin brass metalwork and white canopy. Bowl enamelled lilac grey, with central prismatic glass lens.

Throughout the history of interior lighting, designers have studied the decorative element in fittings, and the beauty of styles evolved in past centuries is still reflected in many designs produced today. At the same time, fittings design has kept pace with changing fashion in decoration and furnishing, so that there is a demand today for fittings that are contemporary in conception, as well as for those based on older-established decorative themes and others which reproduce period styles dating from the years before the electric lamp was known.

All these aspects are represented in a major programme of new fittings just introduced by the G.E.C. Several of the examples illustrated in these pages are from the new contemporary range, which offers a choice of colour and finishes to satisfy every demand for every kind of fitting, be it for home, shop, or office building. Additional interest is achieved in many of the designs by the subtle introduction of a degree of decoration to enhance the basic functionalism so necessary to good contemporary design. New fittings in the commercial range also reflect contemporary influence.

A selection of fittings from the new range is illustrated here. An interesting contemporary variation of the pendant style is seen in F34042, in which the decoration of the cherry red shades offsets the functional simplicity of the satin brass suspension with white relief. The cluster arrangement may also be varied to suit the wish of the user. In other single

light pendants such as F40100 the decorative piercing of bowls and shades has been used to lighten the appearance of the fittings when illuminated, and interest is achieved without impairing the simplicity of line. In the F34048 pendant the shades are available in various colours and designs giving a choice of nine different combinations.



F34048.—Pendant for six 40W. Osram lamps. Satin brass finish with card shades, either black or red with white stripes or red with white polka dots.

F36091.—Ceiling fitting with F2725 bowl. The tapered shaft is Burma teak with polished brass finial. Bowl champagne flashed opal glass, 18 in. diameter. For 3-60W. Osram lamps.

F38038.—Table standard in polished brass with Burma teak shaft and pleated shade in cream Rilfoil. Shade 22 in. diameter. Height 19½ in. For 1-60W. Osram lamp.

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# NEW PRODUCTS: LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

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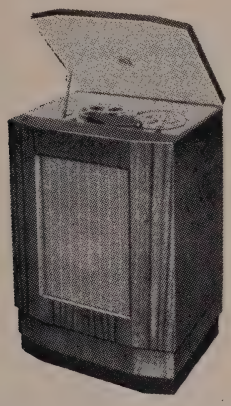
## H.M.V. HIGH FIDELITY TAPE RECORDS AND MAGNETIC TAPE REPRODUCER MODEL 3030



Heralding a brilliant new era in musical reproduction, H.M.V. presents for the first time in New Zealand, High Fidelity Tape Records and Tape Record Players.

H.M.V. High Fidelity Tape Records give to the world a purity of tone that has made recording history, a quality that is unsurpassed, a musical magnificence to set recording standards for decades to come. One tape contains up to an hour's music . . . . for example, two Beethoven concertos or two Schubert symphonies, or 40 minutes' dance music. The list is large—and it will keep on growing!

The new Magnetic Tape Reproducer, Model 3030, has been designed for playing the H.M.V. High Fidelity Tape Records. It offers a high standard of reproduction with the inherent advantages of these remarkable new records, wide frequency range, negligible background noise, and constant quality from beginning to end of the record because of the constant speed of the tape past the head.

The instrument incorporates fast re-wind and forward "skip" facilities, and the interlocked controls prevent accidental use of the wrong control during operation.

Additionally, Model 3030 offers full facilities for making home recordings on Emitape. Among its advantages in this connection are: immediate playback; monitoring facilities both before and during recording; alternative inputs for crystal microphone (available separately), or for mixer, pre-amplifier, etc.; safety lock to prevent accidental erasure. Up to 30 minutes' recording can be made on a 7 in. reel, and the recorded frequency range is 50–10,000 c.p.s.

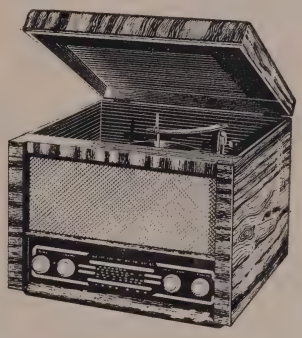
As pictured above, Model 3030 is contained in a strikingly handsome highly polished cabinet with metal loundspeaker grille.

Any "His Master's Voice" Dealer will be glad to arrange a demonstration of this versatile instrument.

* * *

## FIVE-VALVE MULTIWAVE TABLE-GRAM

Radio (1936) Ltd., P.O. Box 1166, Auckland, has just released a most attractive table model radio-gram that is not only a fine piece of furniture but also a highly efficient radio-gram.



The cabinet is of pleasing line and features selected walnut veneers. A gently sloping lid breaks up any suggestion of severity of line. The large, attractively designed dial which extends almost the full width of the cabinet, is floodlit, easy to read and colourful.

Station recognition has been made easy and includes, as part of the design, the call sign of New Zealand and Australian stations on the broadcast band. Shortwave coverage is from 6–19 megacycles.

Ivory knobs with an inlaid gold line add an attractive finishing touch.

The gram unit is a Garrard 3-speed automatic changer which will handle all types of records from standard 78 r.p.m. to 33⅓ r.p.m. The unit is housed in a compartment that is easy to get at and is flock-sprayed to absorb surface noise. The whole cabinet is mounted on felt discs to prevent damage to table tops or other occasional furniture.

The receiver is a 5-valve multiwave receiver that incorporates the latest design and technique. It gives excellent reception on broadcast and shortwave bands. The speaker is a Rola 6-9H elliptical speaker that ensures a most pleasing tone.

**Specifications:**

Tubes: 1-6BE6, 1-EF41, 1-6AT6, 1-EL41, 1-6X4.
Speaker: Rola 6-9H.
Band coverage: 1600-550 KC.; 19-6MC.
Output: 3 watts.
Cabinet: Selected Walnut Veneer.
Dimensions: 18½ in. wide, 14¾ in. high, 18 in. front to back.
Gram. Unit: Garrard R.C. 110.
Price: £55.

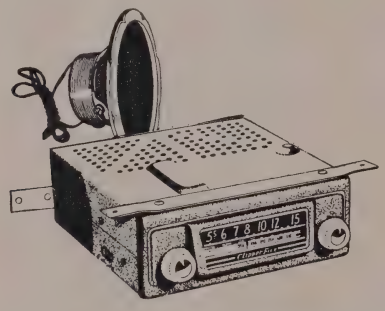
# New Products

(Continued from previous page.)

## CLIPPER "5" HAS WIDE APPEAL

The new Clipper 5-valve car radio from G. A. Wooller & Co. Ltd., has been designed specially for the small car, although its many popular features give it distinct advantages for all types of vehicles.

Brother to the highly successful Clipper "8", this compact model has the same easy mounting facilities and identical frontal layout. However, in the case of the Clipper "5", the overall size is only 7 in. wide, 2½ in. high and 7 in. deep.



The speaker is a 5 in. Celestion, supplied with an interconnecting lead and plug for flexible installation. The owner or serviceman can, therefore, easily place it wherever most suitable. When required, a speaker mounting is available at 8/5d. extra.

Large clear numerals and station call signs make accurate tuning a simple matter, and the push-pull audio output gives a reserve of power for high quality, balanced reception. A tone switch for speech or music is also provided. Both 6 and 12 volt models of the Clipper "5" have a smart, silver-grey hammer finish with matching metal inserts on the dial knobs.

Taken all round here is a really fine performer, retailing at £25 15s. throughout New Zealand. Motorists will find the Clipper "5" very good value.

All Clipper radios are manufactured in New Zealand by the Akrad Radio Corporation Ltd., Waihi and distributed by G. A. Wooller & Co. Ltd., Head Office, Box 2167, Auckland and branches at 43 Lower Taranaki Street, Wellington, and 16–18 Victoria Street, Christchurch.

* * *

## WELWYN VITREOUS-ENAMELLED TOROIDAL POTENTIOMETERS

The range of Toroidally Wound Potentiometers manufactured by Welwyn Electrical Laboratories Ltd., of England, is designed to give an electrical performance meeting all normal requirements, and to provide the greatest robustness without excessive weight. The assembly uses only metal and ceramic or vitrified materials and, since no organic materials are used, there is a large margin of safety under overload conditions and no possibility of tracking between live and earthy parts.

The resistance element is toroidally wound on a ceramic ring using nickel chromium or copper nickel alloy in the form of wire or tape. The element is then covered with a vitreous enamel which also serves to secure the ring to the ceramic base. The ring is thus supported over its entire circumference and the component will withstand severe conditions of shock and vibration. The resistance wire is held in place and protected against accidental damage by the enamel. In addition, the effective heat dissipation is increased, thus improving the efficiency of the component.

The operating spindle is completely isolated by a ceramic bush from the live parts. It has a positive and smooth action over the whole angle of adjustment. The robust end stops act directly on the spindle and no damage can be occasioned to the wiper by attempted over-travel.

The construction of the wiper arm is such as to separate the functions of current carrying and contact pressure. The pressure is provided by a helical spring and can be graded to suit the gauge of resistance wire. The material of the wiper contact is such as to avoid oxidation when the setting remains fixed for any length of time and to provide low contact resistance, thus ensuring freedom from local hot spots in the resistive element. All sliding contacts are of large area, giving a low rate of wear and long life.

Three terminals are provided on all sizes enabling the components to be used as variable resistors or as potentiometers. Units can be supplied with an "off" position at either end where the wiper rides clear of the element. It is recommended that this facility should not be used to break the flow of current.

These potentiometers, together with other Welwyn products, including carbon, wire-wound and vitreous enamelled wire-wound resistors, are distributed by Amalgamated Wireless (Australasia) Ltd., P.O. Box 830, Wellington and P.O. Box 1363, Auckland.

## TURMIX INFRA-GRILL

S. Gordon Anderson Ltd., of 67-69 Endeans Buildings, Queen Street, Auckland, proudly introduces to the New Zealand market the Turmix Infra-Grill, which, by turning to account the latest achievements in the field of infrared technology, has revolutionized griling methods.

The Turmix Infra-Grill, available in three sizes, has a smart and pleasing appearance. It is constructed of the best materials obtainable, the grill plates being made of special alloy. The base and handles are well insulated, and the top cover is highly mobile and "stays put" at any desired level. The grill takes up little room, and is quickly and easily cleaned. It can be used with a maximum of economy, the consumption of both current and fat being low.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# New Products

(Continued from page 40)

## WESTINGHOUSE APPLIANCES COME TO NEW ZEALAND

One of the world's most famous names in the home appliance field, Westinghouse products will shortly be available throughout New Zealand, and distributed by Autocrat Distributors Ltd., Auckland, and their branches in Wellington and Christchurch.

Most members of the trade will know the terrific range of products marketed by Westinghouse.

## THE WESTINGHOUSE FOOD CRAFTER

First release on September 1st will be of the 1955 Westinghouse Food Crafter and the Westinghouse Cook-n-Fryer. It is confidently expected that the greater part of the Westinghouse range applicable to the local market will ultimately be available. Another popular appliance for immediate release is the Kwik-Mix Liquidiser.

Exclusive features, the fact that all products will be up-to-the-minute models, and the prestige of the name Westinghouse, will guarantee the popularity of these products. Inquiries from the trade are welcomed and should be addressed to Autocrat Distributors Ltd., P.O. Box 2364, Auckland.

RADIO OPERATING

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NEW ZEALAND RADIO COLLEGE

26 HELLABY'S BUILDING - - AUCKLAND, C.1

# MISSING AND STOLEN RADIOS

**AUCKLAND:**

AUTOCRAT 6-valve car radio, serial No. 165999; flat type, brown colour, separate speaker.

WESTCO 4-valve car radio; old condition, 2 tuning knobs, oblong dial, golden brown base, black figures, 15 in. diameter speaker, red plate in centre inscribed "Westco".

COLOMBUS auto radio, model 506, serial No. 33985: silver colour.

PHILIPS broadcast model radio, brown plastic cabinet 15 in. x 12 in. x 9in., fitted with light adaptor on flex.

WAYFARER 5-valve blue-grey auto radio.

**ONEHUNGA:**

ARIEL "Seven" car radio, serial No. 4317; converted from 12-volt to 6-volt; brown steel case 11 in. x 8 in.; two white control knobs.

**WELLINGTON:**

H.M.V. Model 524, 6-valve car radio, serial No. 37674 (written in pencil on bottom of tuning unit); 12-volt tuning unit measures 7 in. x 2 in. x 6¾in., volume on and off switch, 5 tuning push-buttons, 4-position tone control, manual tuning, grey enamel casing. Aluminium 6 in. Rola Speaker, model 6L.

**CHRISTCHURCH:**

PHILIPS Model 536 portable radio, chassis No. 63244, licence No. 88531. Maroon bakelite case.

GULBRANSEN 4-valve broadcast model 4154, serial No. 32542, royalty No. 70811; 7½ in. x 9 3-16 in. x 6 in.

**TIMARU:**

PACEMAKER 4-valve portable, serial No. 41947A; red plastic case with white facings. Piece of paper stuck on top of radio.

## VISIT OF INTERNATIONAL TELECOMMUNICATIONS OFFICIAL

A recent visitor to New Zealand for the purpose of consulting with New Zealand Post Office officials was Mr. S. H. Witt, an Australian and an international personality in the technical sphere. Mr. Witt is a member of the International Frequency Registration Board—the group of high level technical experts which sits at Geneva as part of the world-wide radio organization administered by the International Telecommunications Union.

Formerly a member of the Postmaster-General's Department in Australia, Mr. Witt was responsible for building up comprehensive departmental research laboratories in Melbourne. Since his appointment as Australian Commonwealth representative on the Commonwealth Telecommunications Board in London in 1947, he has taken a leading part in subsequent works of this board, and the International Frequency Registration Board which at present is carrying out directives of the special frequency conference held in Geneva in 1951.

In New Zealand the frequency register is maintained and administered by the Post Office, which maintains constant collaboration with the International Frequency Registration Board in Geneva.

The position of members of the latter board is unique in that they are regarded as international public servants, being expressly prohibited from communicating with any Government, including their own, in carrying out their duties. Board members are elected with regard to world-wide representation, and Mr. Witt, an Australian, has special knowledge of the South Pacific area.

The board requires a full understanding of all areas from the economic, geographic and population distribution standpoints, and Mr. Witt's visit brought him up to date with New Zealand's requirements.

Set up by an international conference at Atlantic City in 1947, the International Frequency Board administers the use of the radio frequency spectrum, fixing in effect the radio space for world service in broadcasting, international telephones and telegraph, ships, aircraft and safety services of various kinds to avoid national interferences. One of its tasks is the preparation of a world plan for short-wave broadcasting. International conferences of the Telecommunications Union issue directives under which the board works.

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# TRADE WINDS

## CORRECT ADDRESS FOR CHRISTCHURCH BRANCH OF PYE (N.Z.) LTD.

We apologize for having published in our June issue the incorrect address for the Christchurch Branch of Pye (N.Z.) Ltd. This is located at 16-18 Victoria Street, Christchurch.

* * *

## RADIO (1936) LTD.'S ANNUAL BALL

On Thursday, June 16, a most successful and enjoyable ball was held in the Peter Pan Cabaret, Auckland. Voted to be the best yet, the Annual Ball of Radio (1936) Ltd. included many innovations that added to the general enjoyment and festive spirit.

Three hundred guests were received by the Managing Director, Mr. D. T. Clifton-Lewis and Mrs. Clifton-Lewis who wore an "A" line blue-grey brocaded frock trimmed with silver bugle beads.

A continental atmosphere was introduced in the excellent table service offered by attentive stewards. The spendid dance programme was ably controlled by the Master of Ceremonies, Mr. J. Carter, who kept interest alive with novelty items, novelty dances and competitions that, quite literally, had everyone on their toes all evening.

The cabaret was appropriately decorated with signs, murals, shrubs, ferns and flowers and each guest received a souvenir card to mark the occasion on which Radio (1936) Ltd. celebrated 34 years in business.

The official guests included Mr. and Mrs. A. Boulton (Allan C. Boulton, Paeroa), Mr. and Mrs. L. D. Kerr (Denham Kerr Ltd., Wellington), Mr. B. Cocksedge (B. J. Cocksedge Ltd., Wellington), Mr. and Mrs. D. Alexander (Farmers Trading Co. Ltd.), Mr. and Mrs. D. Yuill (Farmers Trading Co. Ltd.), Mr. and Mrs. J. Drought (Auckland Photo Engravers Ltd.), Mr. and Mrs. J. Follick (Korma Distributors Ltd.), Mr. and Mrs. C. R. Peoples (C. R. Peoples and Co. Ltd.), Mr. and Mrs. R. Fitt (G. A. Wooller and Co. Ltd.), Mr. and Mrs. D. J. Reid (David J. Reid Ltd.), Mr. and Mrs. H. Wilson (Webbs Radio Ltd.), Mr. and Mrs. R. Gatenby (Lectricals Ltd.), Mr. and Mrs. B. Grimmer (Refrigerators Ltd.), Mr. and Mrs. J. Rowe (Signcraft Ltd.), Mr. and Mrs. A. Nicholls (Signcraft Ltd.), and Mr. and Mrs. A. Bell (Bell Mrs. J. Nicholson (Electric Utilities Ltd.).
Radio and Television Corporation Ltd.).

The committee consisted of Miss E. Tilsley, Mrs. A. G. Pellet, and Messrs. W. J. Murphy, W. A. Hamshaw, D. S. Lamb, J. H. Mills, D. E. Mayson, D. A. Hibbs, E. J. Fernie.

* * *

## INCORPORATED PRACTICAL RADIO ENGINEERS

It is with pleasure that we announce the appointment of Mr. E. F. Marker, of P.O. Box 2839, Auckland, as the New Zealand Representative of the Incorporated Practical Radio Engineers.

This Association, founded as The Institute of Practical Radio Engineers in 1936, is an independent professional body with membership limited to those who are actively engaged in any branch of radio, television, electronics or telecommunications. It has no connection with any other trade or professional organization whatever, and should be regarded as a practical and scientific institution only. The words "Practical Radio", therefore, should be viewed in general as applicable to all branches of the electronic spheres of endeavour within the industry at large. The registered objects of the association are:

To promote, encourage, foster and improve the science and practice of practical radio engineering.

Knowledge is disseminated by the association holding at various times and places lectures largely of a practical nature, at the termination of which open discussions are permitted and questions put to lecturers. Technical and other papers, written by members, are published in "The Practical Radio Engineer", the quarterly journal of the association, which is supplied to members free of cost. Co-operation with employers of practical radio technicians is fostered to enable them to contact the association when in need of qualified members or trained students. During the war, the I.P.R.E. was called upon to furnish members for important electronic work as civilians, both in the R.A.F. and A.I.D.

Examinations are held at such times as may be considered necessary for the purpose of proving the qualifications of candidates for entrance or up grading.

Those requiring further information about "Incorporated Practical Radio Engineers" should communicate with Mr. E. F. Marker, who will be pleased to furnish the required details.

* * *

## OVERSEAS TRAVEL

"Itchy Feet" seems to be a prevalent disease amongst the executives of the New Zealand radio and electrical trade these days. Recently returned from a quick visit to Australia are George Wooller and Tom Spencer of G. A. Wooller and Co. Ltd., Auckland, while Don Cooper of Green and Cooper, Wellington, is feeling the cold in the capital city since his return from a brief tour of the Pacific Islands.

Another Wellingtonian travelling afar is Walter Green of W. S. Green and Co. Ltd., last heard of enjoying the warmth of Milan, Italy.

* * * *

## PYE INDUSTRIAL TELEVISION

Pye of Cambridge, pioneers of industrial television, have for several years carried out a programme of intensive research to develop television equipment which will satisfy the exacting technical demands of industry, while being moderate in initial outlay and subsequent operating costs.

The applications of such equipment range from the examination of prototype jet aero engines to the simultaneous facsimile transmission of blueprints and documents from one factory building to another, besides those connected with defence projects which cannot be divulged at present.

Where it is necessary to watch a scientific or industrial process in detail from a viewpoint where it would be dangerous, inconvenient, or even impossible to place a human being, Pye industrial television

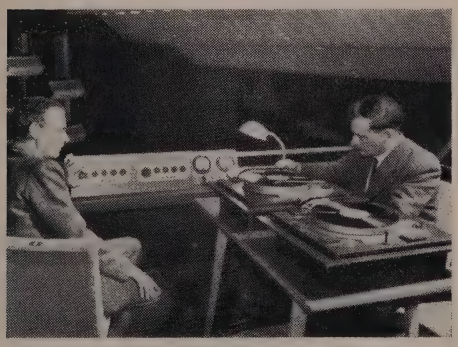
*Demonstration by Pye Industrial TV at Otahuhu Brewery.*

equipment will become a critical observer in the most efficient and economical manner possible.

The advantages of TV microscopy are numerous. The research worker need no longer peer down a single eyepiece of restricted aperture. Instead, a well-defined picture of a selected portion of the specimen may be viewed with both eyes in complete comfort, bright enough to allow photographic records to be made without specialized apparatus. Since a monochromatic picture is produced, the exact effect of any suitable colour filters may be studied carefully before exposures are made. Furthermore, a number of observers may see the picture simultaneously, a feature of great value to medical schools, technical training establishments and other educational organizations.

The demonstration at Dominion Breweries Ltd., Otahuhu, featured above, is another example of the adaptability of Pye Industrial Television equipment.

## THE QUAD II AMPLIFIER AT THE ROYAL FESTIVAL HALL.



*Messrs. P. J. Walker and A. Collinson at the controls of the Quad II Amplifier and turntable during the recent Audio Lectures given at the Royal Festival Hall, London.*

* * * *

## NEW OFFICES FOR G.A. WOOLLER AND CO. LTD.

G. A. Wooller & Co. Ltd. in Auckland have recently taken over several hundred feet of new floor space for offices, showroom and storeroom on the lower ground floor of Chancery Chambers, the building where their present offices are situated.

The photograph shows the reception section with executive and sales offices at right and storeroom to the left, whilst the showroom and model kitchen can just be seen in the background.

The Sunbeam Cooker Deep Fryer, the Mixmaster and other Sunbeam appliances are very much in evidence in the model kitchen where the Dispos-o-matic food waste disposer has also been installed so that visitors are able to see this appliance in actual operation. Showroom space is also devoted to the range of Clipper Radios, Crosley Shelvador Refrigerators and Home Freezers, Whirlpool Washers, and many other Wooller lines.

Those who remember the original Wooller offices immediately post-war, which later also became Pye offices, will realize the tremendous expansion that has taken place in the last few years. It is only recently that Pye (New Zealand) Ltd. has moved into new offices in Imperial Buildings, Queen Street, and now the new offices in Chancery Chambers denote a further expansion.

## MR. COLIN CARNACHAN

Some Sunbeam dealers, notably those around Auckland, Taranaki and Palmerston North areas will already have met Colin Carnachan, "Sunbeam Man" for the "Sunbeam People", G. A. Wooller & Co. Ltd.

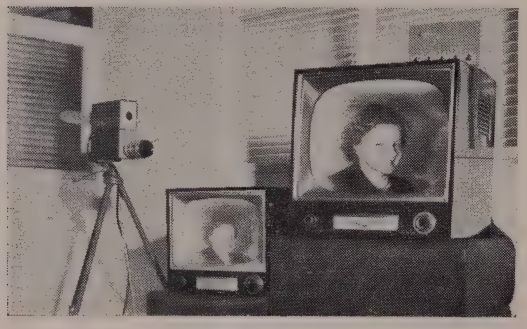
Colin joined G. A. Wooller & Co. in June and made his debut at a Sunbeam dealer conference at New Plymouth, also attended by George Wooller, Ray Fitt (sales manager) and "Miss Sunbeam", who gave practical demonstrations of Sunbeam home appliances in action. Other dealer conferences have been arranged, and will, in future, be a regular feature of Sunbeam sales promotion, together with regular demonstrations conducted by "Miss Sunbeam".

Colin Carnachan (by the way, the second "c" is silent) had an extensive training course on the production and sales side of Sunbeam appliances at the Campsie and Mascott plants in Sydney before joining G. A. Wooller & Co. Ltd. And before that he was, at one time and another, a fighter pilot and a schoolteacher. Colin is an Aucklander, but dealers outside the Great Metropolis should not hold this against him.

All in all Colin Carnachan brings a wealth of varied experience to his Sunbeam job and we wish him all success in his new venture.

* * *

## A.W.A. TELEVISION



At the recent Christchurch Industries Fair, Amalgamated Wireless (Australasia) Ltd. provided the first public TV demonstrations in that city. Generally, the quality of programmes available for televizing was of a high standard, due, in no small measure, to the efforts of Jack Maybury, who in addition to the nightly heat of the talent quest, ran his weekly shows "Scoop the Pool" and "Number Please". The last two were recorded on tape and broadcast at a later date. Wide public acceptance was accorded the twice daily General Motors show "Previews of Progress", which took the form of a series of scientific demonstrations amongst which were the breaking of crystal wine glasses by sound waves and the transmission of music on a light beam. As well as providing one to two hours of televized film per day, A.W.A. also demonstrated the two-way television telephone.

The equipment used was manufactured by Radio Corporation of America, the camera and control unit being the well-known R.C.A. miniature TV equipment, the smallness of the camera being achieved by the use of the R.C.A. development, the 6198 Vidicon Pickup Tube. The smallness of the face of the 6198 facilitates the use of standard 16 mm. movie projector lenses, and fortunately, a French firm has produced the first 16 mm. "zoom" lenses, some of which A.W.A. was able to procure for use at the Christchurch Fair. These lenses have a maximum aperture of F/2.8, and can be "zoomed" over the range 20 to 60 mm. focal length, while, of course, retaining focus independently of the zoom control. The use of a zoom lens dispenses with the need for a lens turret, thus simplifying the cameraman's work considerably.

Outstanding among the 14 TV receivers used in Christchurch were the latest 24 in. R.C.A. Victor receivers, the largest to be shown in New Zealand to date. Prior to the appearance of these, the 17 in. was the largest, and it is interesting to compare the two in the accompanying photograph. Actually, the 24 in. receiver has about twice the screen area of a 17 in. Some of the latter use a new series of 600 ma. heater valve types specially designed for series heater, transformerless operation, which is now being adopted in U.S.A. It is interesting to compare the warm-up time of British and American series heater TV receivers, as the former need about three minutes, whereas the American require only 45 seconds!

At the Christchurch Fair, Closed Circuit Wired TV was employed, this being considered preferable to transmission mainly because of the extremely high interference present at Fairs. This would be difficult to over-ride if normal propagation was employed, whereas Closed Circuit provides a steady, noise-free picture and considerably reduces the equipment required.

In addition to showing the usefulness of television in operating theatres of the Auckland and Wellington Hospitals during July and August, it is hoped to demonstrate the R.C.A. equipment at the forthcoming Wanganui Fair in August-September, 1955.

For surgical work the TV camera is ideally suited for the instruction of students and nurses in dental anatomy and operating techniques. Indeed, the R.C.A. miniature camera, which weights only 4½ lb. when mounted on the operating light, provides a better picture than that obtained by onlookers in the operating theatre.

These demonstrations would not be possible but for the Vidicon Tube developed by R.C.A. Recently R.C.A. have improved this tube and now claim a resolution better than 600 lines—truly remarkable when one considers that the scanned area size is only ½ in x ⅜ in.

A further development is a tricolour vidicon where the three-colour signals are formed by using only one scanning beam. This tube is still in the developmental stages, and it will be probably a year before equipment using it becomes commercially available. In the opinion of R.C.A., with these new developments, the days of the image orthicon are numbered. Already the vidicon is capable of providing better results under some conditions of television broadcasting, and better signal to noise ratio than the image orthicon, while equipment requirements and operating procedure are greatly simplified with the vidicon.

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# THE QUAD II AMPLIFIER

*(Abridged from a report written by P. Wilson, and originally published in "The Gramophone," September,* 1954.)

To anyone of even a moderately technical turn of mind, the mere description of the Quad II amplifier and control unit (as the pre-amplifier is quite properly called) will place it at once, not only in the class of high quality instruments, but quite clearly in the front rank of that class.

It is certainly the most flexible in design that I have yet come across. Provision seems to have been made to meet almost any combination of circumstances, whether relating to records or to pickups, that may conceivably be encountered, either now or at any future time.

But that does not, definitely NOT, mean that it is difficult to operate. One only has to insert a plug prescribed for the particular pickup, and then press one or more buttons, as indicated on a chart, to match the particular make of record. But, if you want to increase or reduce the bass or the treble to suit your particular taste or the characteristics of your loudspeaker or of your room, the controls are there ready to your hand, with very useful instructions concerning their use.

I want to stress these points to start with, because I have heard it said that, whilst the design is a comprehensive delight to the engineer, the knobs and buttons will confuse and frighten the non-technical user. I do not believe that there is justification for any such view. Precision in control, which is what the Quad provides, really makes things simpler for the non-technical user.

## SPECIFICATIONS

**Main Amplifier:**

Response: Flat within 0.2 db. from 20 to 20,000 c/s.
Power Output: Rated at 15 watts.
Harmonic Distortion: Less than 0.1% at 700 c/s. at 12 watts; less than 1.5% at 30 watts.
Sensitivity: 1.4 volt r.m.s. for 15 watt output.
Noise Level: Minus 80 db. referred to 15 watt output.
Output Impedance: 15 and 7 ohms.

**Control Unit:**

Response: Within 0.3 db. from 20 to 20,000 c/s. on gramophone pickup; within 1 db. from 20 to 20,000 c/s. on microphone. Variable on pickup according to setting of controls.
Filter Frequencies: 5, 7 and 10 kc/s. with slope adjustable from level position to 50 db. per octave.
Input Sensitivity: For output of 1.4 volt r.m.s.—radio 100 mv., pickup depending on plug-in unit.
Noise Level: Minus 70 db.
Valves: EF86 and ECC83 in three stage circuit.
Input Impedance: For either radio or microphone—100,000 ohms.
Dimensions: Overall 10½ in. by 3½ in. by 5 in. deep. Chassis opening of 3 in. by 10 in. required.

The principal technical interest in the main amplifier lies in the manner in which the push-pull output stage is arranged. It is a rather unconventional circuit, starting with a resemblance to a paraphase valve. The cathodes of the output valves are also linked through a special winding in the primary of the output transformer, so that there is feedback here as well, which results in a distribution of load between the anodes and cathodes and screens of the output valves.

The output valves thus have the virtues of triodes so far as amplification and output impedance are concerned with some of the advantages of tetrodes in the matter of efficiency. As noted, intermodulation distortion even at 30 watts is remarkably low.

A square wave test shows that the frequency response is well maintained to over 60,000 c/s. when the amplifier is used within its rated power of 15 watts. And it extends in the bass down to below the rating of 20 c/s.

There is thus ample reserve not only of power, but of performance in other respects beyond the makers' specified ratings. Peaks are managed with consumate ease. The performance, in fact, should satisfy the most critical. I have nothing but appreciative comment for it.

The control unit is even more ingenious. I have never seen a unit with such flexibility and convenience of operation. The push-button control is a really brainy idea, particularly the facility for using two or more buttons simultaneously. So is the use of plug-in units for pickup compensation.

The variable slope low-pass filter is a valuable control, particularly for use with old records. It is operated by two knobs: one selects the cut-off frequency—5, 7 or 10 kc/s.—and the other governs the slope, and is adjustable from 1 to 50. One position of the cut-off control is marked CANCEL, and in this position both the tone controls and the filter are out of circuit, and the frequency response is flat. I found this a most valuable facility because it enabled me to check up quite quickly exactly what correction I was applying at any moment.

I need only add that the construction of both units is beyond reproach.

Also, I must add a word of congratulation about the clarity and informative character of the Instruction Book and leaflets sent out with the amplifier. They are a model of what such things should be.

New Zealand distributors of the Quad II Amplifier are Messrs. W. G. Leatham Ltd., 43 Lower Taranaki Street, Wellington, P.O. Box 1284, to whom all inquiries should be addressed. —P.B.A.

# RECORD TALK

By JOHN GRAY

Radio Corporation are among the many record companies currently exhorting you to "Open up your heart and let the sunshine in". The alternative is seemingly to let the Devil in instead, hence the song has a religious slant to it as do several others of the kind. But no one can reasonably quarrel with its philosophy and the locally made version by the Three Lads (Tanza Z 250) can hold its own with many overseas ones. The backing is "Ko Ko Mo". The other Tanza release once again features Daphne Walker with Bill Wolfgramme's Hawaiians in that old favourite "The One Rose", and on the reverse of Z252 Bill's boys oblige with a rousing performance of "Honolulu March".

A number of extended play 45s is steadily being built up on Capitol; the brilliant pianist Leonard Pennario plays well known Spanish pieces, including the Albeniz "Tango", on CEC005, and violinist Louis Kaufman is heard in romantic violin favourites (CEC004), while on 006 is a generous selection from the American Ballet Theatre's production "Princess Aurora", of which the music will be better known here as "Aurora's Wedding" and which all comes, of course, from Tchaikovsky's greatest ballet score, "The Sleeping Princess". For once the recording has been made by an orchestra which plays exclusively for ballet.

Philips are still consolidating their position in the popular field with releases by their impressive lineup of artists. Winifred Atwell is up to form with "Highland Boogie" and "Concerto for Romance" (P26094), and the name of Liberace appears on B21586, but this time it is brother George, who has a record to himself on which he conducts energetic renderings of "Stars and Stripes" and "Madalena". Johnnie Ray is still going strong, in jaunty mood with "Parade of Broken Hearts" and more subdued in "Paths of Paradise" (B21528). Those who warm to instrumental themes from films, which are, in the main, superior to the pointless songs we have heard introduced at the outset of certain non-musical pictures, may be directed confidently to B21227, whereon Paul Weston's orchestra play "Autumn in Rome" and "Indiscretion", both stemming from the film "Indiscretions of an American Wife". Then for a touch of old time party music, Frankie Yankovic may be heard in "Valley Spring Polka" and "One More Dance" (B21147).

I have been enormously impressed by the Philips classical discs; they are steadily mounting up and an interesting repertoire is emerging. For connoisseurs comes Honegger's impressive opera-oratorio, "Joan of Arc at the Stake" (ABL 3033-4) with Vera Zorina reciting the role of Joan and Eugene Ormandy in charge of chorus and orchestra. There is a brilliant version of the "New World" symphony by Antal Dorati and the Hague Philharmonic on ABL 3021, and a Viennese performance of some of Mozart's Masonic Music on ABL 3022. A recently re-discovered violin concerto of Paganini's, No. 4 in D minor, is played by Arthur Grumiaux and the Lamoureux Orchestra on a ten-inch disc, ABR 4024, while also on this handy size of record are four standbys of the orchestral repertoire conducted by the Dutch musician Willem van Otterloo. On ABR 4026, the Brahms Idyll", and on NBR 6014, two of the best known Liszt symphonic variations on a theme by Haydn and Wagner's "Siegfried poems, "Mazeppa" and "Les Preludes". The latest Vienna Boys' Choir record (NBR 6013) is publicized as "Secular Motets", but titles such as "Salvator Mundi" and "Laude alle Vergine Maria" seem to have anything but a secular connection! The conductor is Friedrich Brenn.

We may expect a flow of Mozart issues as the bi-centenary of his birth draws nearer. Philips embarked, some time ago, on a long-term plan of recording representative samples of all his styles of composition (the fantastic project to record literally everything Mozart wrote seems, somewhat mercifully, to have been dropped). Besides the Masonic pieces referred to, the new Philips release has two ten-inch issues devoted to works of the Serenade type. ABR 4010 contains two early "Cassations" delightfully played by Paul Sacher and the Vienna Symphony, and ABR 4018 has a coupling, by the same orchestra under Rudolf Moralt, of the best known of all the serenades, "A Little Night Music" and the equally delightful "Serenata Notturna" for strings and drums.

No new Festival release has come in since my last notes were compiled, which allows me to draw attention, once again, to their enterprising release of Stravinsky's "Les Noces" or "The Wedding", on CFR10-576. For the modest price of a ten-inch LP you obtain a fine performance of one of the masterpieces of our time, a fascinating experiment in sound: it is scored for mixed chorus with an orchestra composed entirely of percussion instruments, including four pianos. The ensemble from the Dresden State Opera under Fritz Schreiber do justice to a difficult score, and no one seriously interested in contemporary music should neglect this issue. For those attracted to more orthodox music there is Klemperer's inspired rendering of Beethoven's great Mass in D major (Festival CFR12-86, two records in an album).

Once again it is difficult to know where to begin discussing the multitudinous releases of the HMV group. A flood of brand new popular records, a revival of some famous ones, an avalanche of LPs, all claim our attention. Perhaps, since old friends are usually the best, we might notice firstly a small group of interesting re-issues. How many people have worn out their copy of the John Charles Thomas "Open Road" (ED 233). This, and its two companion numbers, "Love Can Be Dreamed" and "Thine Alone", come from the Johann Strauss "Gypsy Baron", in which operetta, the number we know as "Open Road" should actually be sung by a tenor. But admirers of J.C.T.'s most popular record should perhaps be advised to run, not walk, to secure their copies. Another old timer is Columbia's DOX 527, "A Fruity Melodrama". ("You lie in your teeth." "False!" "I know, but you lie in them".) Yes, this was one of the funniest records ever made, and older folk would claim they just don't make them as funny nowadays. Going back further still, we find the Gil Dech "Maori Selection" turning up under its original number, DOX234. This is doubtless a pendant to the wholesale revival of Rotorua Maori Choir records.

One or two interesting discs are buried in the International Section, notably some traditional Tongan melodies sung by Palu Tupou and Veiongo Fakaua, who are actually ladies in waiting to Queen Salote. There are three discs, HMV JO 410-412. A German child called "Die Kleine Cornelia" makes a decided hit with "Pony Serenade" on HMV EG 7911, and the Black Sea Cossack Choir are on safe ground with "Monotonously Rings the Little Bell" (Columbia DCW25) which recalls memories of a best-selling record made years ago by the original Don Cossacks.

The Ted Heath fans, now doubtless a larger body than ever before, will seize Decca F 10425 featuring "Dig Deep" and "Asia Minor." Kay Starr's HMV debut is in a number called "If Anyone Finds This, I Love You" (HR 10071). This has an original if sentimental twist to it. "Open Up Your Heart" is given a "straight" rendering by George Beverley Shea on HR 10073. Eddie Fisher has not been over-prominent of late but his fans will find much to please them in his latest coupling of "A Man Chases a Girl" and "Wedding Bells" (HR 10069). A previously unreleased Decca of Winifred Atwell's couples "Big Ben Boogie" with "Winnie's Waltzing Rag" (Y6692). Two up and coming tunes, at the time of writing, are "Cherry Pink and Apple blossom White", sung by Alan Dale on DNZ 59, and the latest Joni James ballad, "How Important Can It Be" on MGM 5191. Then there are two LPs of sound track recordings from recent successful films: "White Christmas" on Columbia 330SX 7506, and "Seven Brides for Seven Brothers" on MGM 01-7503.

Two great orchestral conductors of the immediate past, the late Furtwangler and the retired Toscanini, are still regularly represented in HMV's lists. Furtwangler adds yet another to the endless procession of performances of Beethoven's fifth symphony (ALP 1195) and is the latest to couple the Strauss tone poems "Don Juan" and "Till's Merry Pranks" (ALP 1208)—versions which may be safely recommended to his loyal following. Toscanini is heard in the Haydn-Brahms Variations, always a speciality of his (ALP 1204) and breaks fresh ground, for him, with its companion piece, Elgar's Enigma Variations. Hitherto this work has remained the exclusive property, on records, of English conductors, most of whom have done it at some time or other, the latest being Sir Thomas Beecham on a forthcoming Philips release. But there can be no question of Toscanini's ability to penetrate to the heart of these masterly variations, and the recording is one of the best he has ever had. Very highly recommended. The month's opera from HMV is a new Rome recording of "Madame Butterly", with the enchanting Victoria de los Angeles in the title role and the caddish "hero" sung by Giuseppe di Stefano, who seems indispensable for the tenor roles when Italian opera is to be done on records. The concensus of opinion would seem to be that the whole opera is carried by de los Angeles, which is as it should be. Such consistently beautiful singing can rarely have been heard throughout a long opera (ALP 1215-7). For myself, nothing will ever replace Toti dal Monte, who sang with Gigli in the old HMV set, but that is merely a strong personal reaction

(Continued on page 50)

# AROUND AND ABOUT

## CHECKING RADIO-FREQUENCY TRANSMISSION

A new radio call sign came on the air during May: It broadcasts once a week for three hours as a standard for calibration of transmitters.

The new call sign is ZLFS, and each Tuesday afternoon, between 1 p.m. and 4 p.m. it broadcasts at two-and-a-half million cycles per second from the D.S.I.R.'s Dominion Physical Laboratory at Gracefield Road, Lower Hutt. The power is 35 watts, giving a useful range of 50 miles or so, and the transmission is not modulated: that is, the carrier wave only is transmitted and speech or music is not broadcast.

This small transmitter gives New Zealand for the first time a Standard Frequency Transmission, and allows radio engineers and amateur radio transmitters to check their frequencies and it assists them to keep to the frequency assigned to them by international agreement. Previously New Zealand has had to depend on the standard frequency transmission from Honolulu, but the signals from there are very often multilated and somewhat unreliable by the time they reach New Zealand.

The Dominion Physical Laboratory uses an oscillator that is controlled by a quartz crystal of a type that is particularly stable, and has a frequency of 100,000 cycles per second. The output of the oscillator is amplified to 35 watts, and the frequency is increased to two-and-a-half million cycles a second, with an accuracy within a quarter of a cycle. Accuracy is maintained by cross checks from four good quartz crystals running continuously, and by comparing the New Zealand transmission with that of Honolulu when this is undistorted.

The Dominion Physical Laboratory is seeking comments on the use made of it from stations receiving the New Zealand Standard Frequency Transmission and the Laboratory would appreciate suggestions.

## C.B.E. TO MR. F. N. SUTHERLAND, GENERAL MANAGER OF MARCONI'S WIRELESS TELEGRAPH CO. LTD.

In recognition of his outstanding services to British industry, Mr. F. N. Sutherland, M.A., M.I.E.E., General Manager of Marconi's Wireless Telegraph Company Ltd., was created a Commander of the Order of the British Empire in the 1955 Birthday Honours List.

He was appointed General Manager of Marconi's Wireless Telegraph Company in January, 1948, after serving for twenty-six years with The English Electric Company, with which Marconi's is associated. After taking his degree at Cambridge in 1922, Mr. Sutherland joined "English Electric", being appointed the company's Chief Engineer in South America in 1925, and in 1930, General Manager for Brazil, with headquarters at Rio de Janeiro.

Departing from Brazil in 1936, Mr. Sutherland was appointed Managing Director of the English Electric Company Ltd. in South Africa, with headquarters at Johannesburg, his territory covering the Union of South Africa, Southern and Northern Rhodesia and Portuguese East Africa. He was also territorial manager for Nyasaland, Tanganyika and Kenya.

During the war, Mr. Sutherland frequently visited England in connection with supplies of electrical plant for the manufacture of munitions in South Africa. He was also responsible for the building of the "English Electric" Benoni Works, near Johannesburg.

Shortly after leaving South Africa in December, 1947, Mr. Sutherland was appointed General Manager of Marconi's, and under his leadership the Wireless Telegraph Company has further enhanced its world-wide reputation for superlative skill and service in the field of radio engineering.

## NEW ZEALAND ORDERS REDIFON R.50M COMMUNICATIONS RECEIVER

A contract to supply twelve R.50M communications receivers has been placed by the New Zealand Post and Telegraph Department with Redifon Limited.

The R.50M fully complies with the New Zealand P. & T. specifications, and it is intended that this shall become standard equipment.

Although designed primarily as a main receiver for ships, the R.50M is now firmly established throughout the world as one of the finest general communications receivers. Its wide frequency range of 13.5 kc/s. to 32 Mc/s. is unmatched in so compact a unit or one offered at so reasonable a price.

Special versions are made with very high ratio drives for the precise tuning of C.W. signals, and others are available for use in conjunction with an adaptor unit to operate teleprinters or other recording apparatus.

* * * *

## FERROVOICE PLASTIC TAPE

Magnetic Coatings Ltd., of London, has recently introduced a new Ferrovoice plastic tape said to incorporate all the latest developments in tape production.

Features of this new tape include pre-stretched PVC, high output, low background noise, non-curling, and high tensile strength. Further details may be obtained from the New Zealand distributors, Messrs. Fred Rothschild and Son, P.O. Box 170, Lower Hutt.

* * * *

## E.M.I. TAKE OVER "CAPITOL" RECORDS

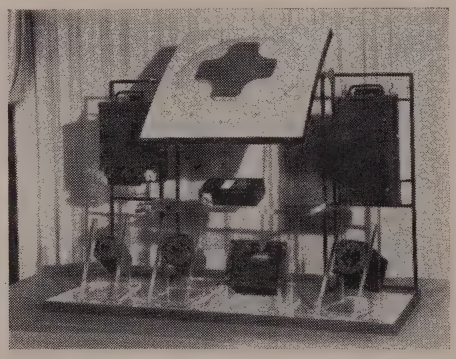
Electric and Musical Industries Ltd. announces that it has entered into a contract to purchase the majority of the 476,230 common shares of Capitol Records, Inc., of California, U.S.A., and is offering to purchase the balance of the common shares.

* * * *

## PARIS AIR SHOW

### Last-minute Release of Revolutionary Subminiature Radio Compass.

The Marconi light-weight subminiature Automatic Direction Finder, Type AD722, for use in aircraft, appeared in public for the first time at the Paris Air Show on June 10, just after its release from security classification.



*Main units of the Marconi Subminiature Direction Finder, Type AD722.*

This new radio compass, manufactured by Marconi's Wireless Telegraph Co. Ltd., and designed for use in the M.F. band, is believed to be the smallest and lightest of its type yet developed to such an exacting specification; the total weight of the main units is less than 10 kg. It has been developed for use in all types of aircraft, and is primarily intended for pilot operation.

The direction finding system provides one of the many outstanding features. Contrary to conventional practice, the receiving aerial is fixed, being in the form of a sealed iron-cored crossed loop having no moving parts, and which has a maximum height of less than $\frac{3}{4}$ in. A low drag loop installation can therefore be achieved without recourse to full suppression, or alternatively the aerial may be fully recessed into the fuselage if desired. Even in the latter case it is not necessary to cut a large hole in the fuselage.

A Bellini-Tosi type of direction finding system is employed, the goniometer being embodied in the bearing indicator. Bearing

presentation is by means of a scale pointer, driven directly from the shaft of the goniometer search coil. There are two sizes of indicator, 3½ in. and 2½ in. dia. to allow for variations in available cockpit panel space.

Should a suitable bearing indicator of another equipment already be incorporated in the pilot's instrument panel, this may also be used in conjunction with the subminiature radio compass, with consequent economy of space and capital outlay. For this purpose a coupling unit is provided which includes a synchro element for transmission of the bearing indication to the slave indicator on the pilot's instrument panel. Transfer of the slave indicator from the other equipment to the radio compass, and vice versa, is made by remote switching.

The receiver circuits of the new automatic direction finder are contained in two rack-mounted main units, and are remotely operated from a single control unit. Plug-in sub-units are used for ease of replacement. The frequency coverage is 200-1700 kc/s, covered in three ranges.

A further valuable saving of space and weight is achieved by dispensing with the usual rotary transformer, as the 28V DC aircraft supply is used directly for H.T.

A portable test set which will check the main units and each of the plug-in sub-units has been designed specially for this equipment. This test set will greatly simplify servicing procedure.

The Marconi subminiature automatic direction finder meets, in spite of its greatly reduced size and weight, all the major operational requirements for this type of equipment and is not merely a "homer".

### BRITISH RADIO LEADS THE WORLD

With Her Majesty, the Queen, as patron, the British Radio Show will be held at Earls Court, London, from August 24 to September 3, 1955. It will be a brilliant display of the purposeful progress which Britain continues to make in the fields of Radio, Television and the many applications of radio engineering. There will be 121 exhibitors, including all the manufacturers of radio and television receivers. Radio sets will include numerous new models for VHF/FM reception, now coming into use in Britain, and another feature will be multi-channel TV sets for reception of the first commercial transmissions due to commence immediately after the Show.

Nineteen years ago Britain started the world's first Television Service. In the succeeding years, British Television has widened its scope at a truly spectacular speed—today nearly 90% of the country's 52,000,000 population being covered by the B.B.C.'s television network.

A secondary service of sound broadcasting of the three B.B.C. Programmes has commenced on VHF/FM with the aim of bringing better listening to those areas where, hitherto, quality has been spoiled by interference. British manufacturers are fully qualified to supply this type of receiver for use in any part of the world where an F.M. service is in operation.

British television engineers designed and carried out the first international exchanges of television broadcasts. British equipment—including that for the Trans-Alpine links—was used by the eight nations concerned; and British manufacturers are continually applying the skill of these engineers to the design and production of the highest quality television receiving equipment built to the technical standards adopted in any particular market.

The British radio industry is now spending 10% to 12% of production costs—amounting to millions of pounds annually—on research and development, with the result that British receiving equipment of the highest engineering standard and quality, with low maintenance cost, is available for use in any part of the world.

Although little is being claimed until problems of mass production are overcome, it is clear that British firms are in the forefront in the development of transistors, the valves of the future.

British radio exports have expanded from £7.8 million in 1946 to the record figure of £29.2 million last year. There is a steady overseas demand for British receiving equipment of all kinds and for British broadcast transmitters, which incorporate new techniques, including unattended stations.

It was Britain who gave Radar to the world, and British manufacturers have always held the lead in this and other navigational aids. As an example, London Airport control is now the most advanced of any airport on earth.

At recent meetings of the International Electrotechnical Commission, it was apparent that British test standards for radio and electronic components are higher than those of other countries.

Ever since the demand for "hi-fi" sound reproduction began, the exports of British sound equipments and components to Canada and the U.S.A. have mounted steadily, and British audio equipment is being used in the highest grade radio-gramophones manufactured in other countries

Finally, every major British industry now uses British-designed and British-made electronic aids to production.

We think it is true to say, therefore, that the British National Radio Show is of vital concern to everyone interested in this ever-expanding field, and we hope to be able to review this important event in greater detail in a future issue of this journal.

## Publications Received

**From Amalgamated Wireless (Australasia) Ltd.:**
Aerial, April, 1955.

**From British General Electric Co. Ltd.:**
G.E.C. Journal, Vol. 22, No. 1, February, 1955.
Osram Bulletin, Vol. 32, No. 1, January, 1955.

**From H. W. Clarke (N.Z.) Ltd.:**
Westinghouse Engineer, Vol. 15, No. 3, May, 1955.

**From National Electrical & Engineering Co. Ltd.:**
B.I.C.C. Bulletin, Nos. 13 and 14.
G-E Ham News, Vol. 10, No. 2, March-April, 1955.
The National Electrical Review, Vol. 2, No. 10, May, 1955.

**From H. A. Parton Ltd.:**
Jenolite News, Vol. 6, No. 12, Vol. 7, Nos. 1, 2 and 3.

**From Philips Electrical Industries of N.Z. Ltd.:**
Communication News, Vol. XIV, No. 3-4, March-April, 1954.
Electronic Application Bulletin, Vol. 15, No. 4-5, April-May, 1954.
Philips Serving Science and Industry, Vol. 1, No. 4, 1954.
Philips Sight and Sound, No. 6, July, 1955.
Philips Technical Communication, No. 1, 1954.
Philips Technical Review, Vol. 16, No. 1, July, 1954.

**From Radio Industry Council, London:**
British Radio Leads the World—Information on British Radio Show, Earls Court, August-September, 1955.

**From Richardson McCabe Ltd.:**
Muirhead "Technique", Vol. 9, No. 2, April, 1955.

**From Standard Telephones & Cables Ltd.:**
Electrical Communication, Vol. 31, No. 4, December, 1954.

**FOR REVIEW:**

**From Data Publications Ltd., 57 Maida Vale, London, W.9.:**
The Radio Amateur Operator's Handbook—Data Book Series No. 6.

**From John F. Rider, Publisher Inc., 480 Canal St., New York 13, N.Y., U.S.A.:**
(No. 155-4) TV Field Service Manual with Tube Locations, Vol. 4. (1947-1953).
(No. 168-3) Picture Book of TV Troubles, Vol. 3—Video I.F. and Video Amplifier Circuits.

**General Publications Received:**
A.P.A.E. Journal, Vol. 6, No. 2, April, 1955.
Boletin del Centro de Documentacion Cientifica Y Technica de Mexico, Vol. 4, Nos. 2 and 3.
Electrical Industries Export, Vol. 55, No. 5, May, 1955.
The Gramophone, Vol. XXXII, No. 384, May, 1955.
N.Z. Electrical Journal, Vol. 28, No. 6, June, 1955.
N.Z. Electrical & Radio Trader, Vol. 1, No. 12, June, 1955.
The Radio Constructor, Vol. 8, No. 10, May, 1955.
La Radio et TV Revue, Vol. 6, No. 5, May, 1955.
Radio Electronics, Vol. XXVI, No. 5, May, 1955.
Radio & Television News, Vol. 53, No. 3, March, 1955.
Wireless & Electrical Trader, Vol. 97, No. 1273, Component Show Issue, Vol. 98, Nos. 1279, 1280, and 1282.
Wireless World, Vol. 61, No. 5, May, 1955, and No. 6, June, 1955.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*For the Technician*

# H.M.V. HEAT-CONTROLLED IRON No. 1—Part II

**Setting Thermostat**

Proceed as follows:—

(1) Remove terminal cover and slide cover and sleeve along lead for about 3 inches.

(2) Remove fibre insulating strip and disconnect leads. Take off special slotted nuts securing "U" bolt. Note position of spring washers.

(3) Withdraw control knob. Take out thumb rests and clips.

(4) Remove securing screws beneath thumb rests.

(5) Lift off top and remove asbestos yarn insulation between top and sole plate.

(6) Connect leads from iron tester to iron terminals. Replace control knob.

(7) See that the contacts of the thermostat are not either welded together or badly burnt (in either of which cases the entire switch should be replaced) and place the iron on the temperature measuring block.

(8) See that the porcelain cam is in the "H" position.

(9) Slacken the screw locking collar to control shaft and adjust the cam until the thermostat cuts out at 250° C. (looking from back of iron clockwise rotation of cam will decrease temperature and vice-versa). DISCONNECT THE IRON WHILE MAKING THIS ADJUSTMENT.

(10) Allow one or two cycles of thermostat operation to take place and see that the cut off temperature never rises above 250° C., then tighten the locking screw and re-check temperature. Switch off.

(11) when the iron is cool, note that the contacts are made at **all** positions of the heat setting cam.

**Replacing Element**

(1) Do operations 1 to 5 above; then disconnect element tags.

(2) Remove screw securing front of clamp plate.

(3) Remove two screws at rear of thermostat assembly and lift off plate with thermostat.

(4) Remove asbestos pad and element.

(5) Brush sole plate (including bi-metal recess) clean off all grit. Replace in the reverse order using new element and asbestos pad if required.

(6) Re-set thermostat as above.

**Replacement or Repair of Thermostat**

To obtain access, do operations 1 to 5 of "Setting Thermostat" above.

To remove thermostat proceed as follows:—

(1) Disconnect element, remove four screws securing thermostat assembly.

(2) Lift off thermostat complete.

If the silver contacts are slightly burnt, they may be cleaned with fine emery cloth. If the springs have lost their temper due to faulty condenser (A.C./D.C. model) or any other cause of overheating, or if the contacts are welded, due to the iron having been used on wrong voltage mains, or A.C. model used on D.C., replace the thermostat complete. Proceed to "Setting Thermostat" as above.

**Bi-Metal Strip**

It is extremely rare for faults to occur in the bi-metal strip. Extraneous matter under it may prevent it from returning to its flat position, thus preventing the thermostat from switching on again, particularly at low settings of the control. If switching is erratic with consequent wide variations in temperature, check bi-metal fixing screws.

Access to the bi-metal strip is obtained by removing the element (see above).

**Temperature Range**

The total range of temperature the iron is designed to cover is from approximately 150° C. at the lowest (L) setting to 250° C. at the highest.

**Condenser**

On A.C./D.C. irons a 0.02 μf. condenser (Part No. 25074A) is fittted—one end to the bottom left-hand terminal together with the element tag; the other end to the top left hand terminal by means of the screw and washer shown in Fig. 4.

**General Notes on Re-assembly**

(1) When fitting element clamp, screw front screw home first, then two rear screws.

(2) Replace all shake-proof and plain washers in the correct position.

(3) See that the cord in the lead is tied to the cable grip.

**Spare Parts**

Spare parts for this iron can be obtained from **E.M.I. Suppliers (trade division of H.M.V. (N.Z.) Ltd.), 162-172 Wakefield Street, Wellington, P.O. Box 296.**


CLASSIFIED ADVERTISEMENTS

FOR SALE: TRANSFORMER, layer winding machine, single windings, less motor, £25. ELECTRAD, 13 Lower Riccarton Road, Riccarton, Christchurch.

FOR SALE: TRANSFORMER, Multi-winder, 5 to 12 bobbins, complete on bench, with motor and clutch. What offers? ELECTRAD, 13 Lower Riccarton Road, Riccarton, Christchurch.

FOR SALE: 5-inch OSCILLOSCOPE KIT SET, complete with 11 tubes and cathode-ray tube, also steel cabinet, but wiring is incomplete. What offers? J. LOGUE, Manunui, via Taumarunui.

FOR SALE: WILLIAMSON AMPLIFIER, complete for assembly. £25. WOODS, 28 Crieff Street, Wellington. Telephone 27-363.

TO BUY: Back copies Audio Engineering, Electronics, Electronic Engineering, Tele-Tech., Wireless World. OVENS, C/o "R. & E."

# Record Talk

(Continued from page 46.)

Descending gracefully to plum label, we find an extensive selection from the hit musical "Paint Your Wagon" on CLP 1005. The show is now in Australia and may eventually be bound in this direction, the music is in the very best American "outdoor" tradition as inaugurated with "Oklahoma". The Boston Promenade Orchestra offer very full measure on CLP 1030: the overtures to four Gilbert and Sullivan operas on one side, on the other, toothsome selections from four big Broadway shows, "South Pacific", "Annie", "Kiss Me Kate" and "Brigadoon". The fashionable, fantastic, exciting Sauter-Finegan Orchestra are heard in some of their red-hot numbers on CLP 1027, clinically labelled "Inside Sauter Finegan". Some of the individual titles arouse our interest—"10,000 B.C.", "Eddie and the Witch Doctor" and "Finegan's Wake".

From Columbia we have a scintillating version of the Saint Saens "Carnival of the Animals" by the Philharmonia under Igor Markevitch, in which the pianists are none other than Geza Anda and Bela Siki (33CX 1175). It is all recorded very close up and the various effects are astonishingly vivid, indeed a real "guide to the orchestra". The reverse claims to be just that, it is Britten's "Young People's Guide", this time adorned with a narration delivered in the cultured tones of Peter Pears. He does it very well and this could be a marvellous "education" record, but generally I can see no excuse for the introduction of spoken matter on a musical disc, since after about the third hearing it becomes a downright irritation. Even Noel Coward's witty remarks in the rival Philips "Carnival" are surely only for occasional hearing.

Arthur Bliss is a composer who seems to have missed, in the main, the wholesale attention paid by the companies to British musicians. It is thus gratifying to welcome him as both conductor and composer on 33CX 1205, whereon the Philharmonia Orchestra play his really splendid "Music for Strings" and a suite from the dramatic ballet "Miracle in the Gorbals". Lovers of Elgar will find a further attractive grouping on 33SX 1030, the Nursery Suite, the string serenade and the three Bavarian Dances, recorded under the baton of that old veteran of the recording studios, Lawrance Collingwood, with the London Symphony, which in the old days was almost Elgar's own orchestra. A sparkling new set of Dvorak's fourth symphony appears on 33SX 1034. It is well done by the Philharmonia under Wolfgang Sawallisch and is a bargain, for besides being in the cheaper label category, it offers in addition the same composer's endearing "Scherzo Capriccioso".

On Decca comes a praiseworthy issue of all the unaccompanied violin sonatas and partitas of J. S. Bach, played on LXT 2951-3 by Emil Telmanyi, who uses the "Vega Bach bow" which, as shown in the photo on the cover, looks more suited to Robin Hood than to a mere violinist. Some of the leading musical experts of our time are at present arguing fiercely over the merits or demerits of this contraption, so I shall content myself with the modest remark that at last we have all of this wonderful if specialized music, available in handy form and very decently played and recorded. Three other Decca releases demand our attention. There is a very beautiful version of Beethoven's fourth piano concerto by Clifford Curzon and the Vienna Philharmonic under Knappertsbusch (LXT 2948), and a welcome announcement to admirers of Kathleen Ferrier will be that her three Mahler songs which make up the odd side of the "Song of the Earth" set have now been made separately available on a medium-play disc, LW 5123. But the Decca record which has given me most pleasure has been one containing four Mendelssohn overtures, done by the Vienna Philharmonic Orchestra under Carl Schuricht (LXT 2961). I suppose the only really well known one, "Fingal's Cave", must rank as musically the best, but there is equal enjoyment in the exhilarating "Calm Sea and Prosperous Voyage", the rousing "Ruy Blas" and the more exotic "Fair Melusina". Even those inclined to scoff at a nowadays unfashionable composer must admit the mastery of this highly civilized music. Schuricht and Decca have treated it all most handsomely.


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SEVEN RANGES.—With single hand operation and thumb-operated selector switch with position positions.

SAFE.—Can be used with complete safety on bare conductors up to 600 volts A.C. without fear of shock or risk of short-circuiting the conductor to an adjacent conductor or to earth. All metal parts except the actual magnetic contact surfaces are fully insulated.

ACCURACY.—Within 3% of full scale on all ranges. Variation of the position of the conductor from a central position in the frame has only a very small effect on the reading.

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GOOD DAMPING.—Assured by the use of a rectifier type moving coil instrument.

SAFETY GLASS.—The dial is protected by a toughened glass.

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# The Ronette Type PX Pick-up Cartridge

(Continued from page 31.)

the zero line at about 3,500 c/sec., is the pick-up's reaction to the fact that the recording curve has a gradual curvature of the same sort above and below 1,000 c/sec. This is a normal characteristic of all L/P recording curves, and it so happens that the particular record used exhibits it in a more marked degree than most others.

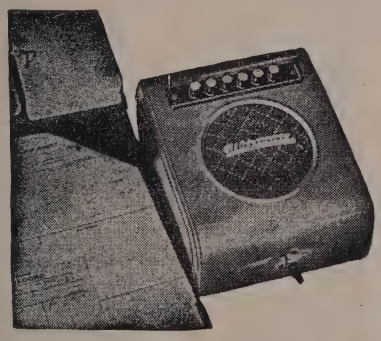
While we have drawn the response curve in a particular way in order to demonstrate an important feature of crystal pick-ups in general (when they are good ones like this), we should point out that the best results will be given by the scheme outlined earlier—namely, using a 120k. load across the pick-up and using equalization as for a magnetic pick-up.

## WEIGHT ON THE STYLUS

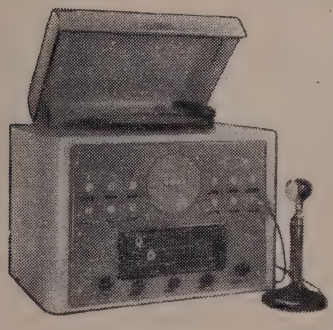
In the course of the experimental work involved in testing the PX cartridge, we found that it was definitely advisable to stick to the needle-point weight recommended by the makers. Not only does this give the best groove tracing, but it also results in the most level frequency response. It says a good deal for the pick-up that it can be used with as small a stylus weight as two or three grams without any audible effect on the reproduction, whereas the optimum weight is in the region of seven grams. With the smaller weight, however, it was noticed that the broad peak in the upper register increased in amplitude by about 2 db., and that 7 grams or more gave the flattest response curve. It should be remembered, too, that the lightest pressure will not necesarily give the smallest record wear, as the tracing at high levels and high frequencies will be slightly worse than with heavier pressures. Too little pressure can cause wear just as does too much.

## CONCLUSION

The PX cartridge certainly lives up to its claim to be an extended response version of the type P, and our outstanding impression is that in other respects it is just as good. The smoothness and lack of intermodulation is most marked, and the reproduction obtained from it can compare on equal terms with that of pick-ups many times as expensive. Above all, one should not make the prime error of thinking that, because the price of these units is so low, their quality is not high. In point of fact, nothing could be farther from the truth, and audiophiles should welcome it as an excellent addition to the range of high-quality equipment available in this country. Sole distributors for this and other Ronette products are Messrs. Green and Cooper Limited, 43 Lower Taranaki Street, Wellington.

Intercommunication



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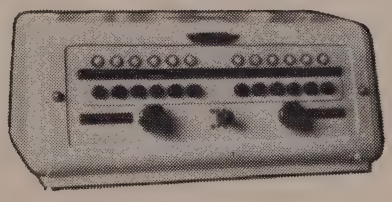
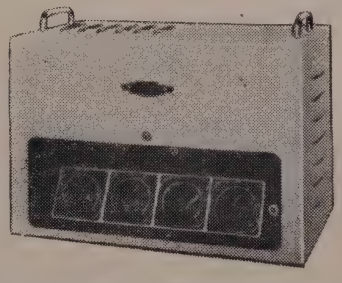


Control Equipment



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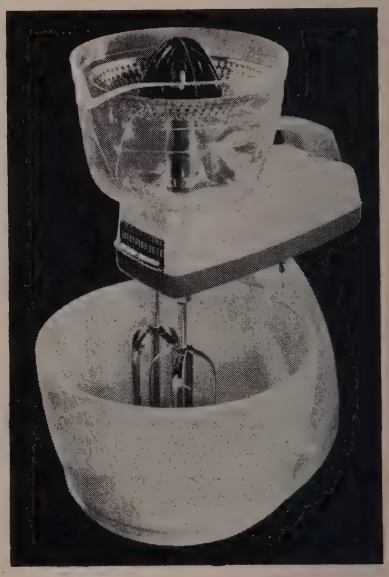

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# Transistor Current Amplifiers

(Continued from page 27.)

100 amp. one, or a 500 amp. one into one reading 50 amps. full scale. If the full gain of round about 40 times is used, one can hardly imagine a more inexpensive or reliable method of obtaining a meter that reads 25 amps. full scale, especially if the meter happens to be one of the well-known war surplus variety!

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Just to give an idea of what can be done with transistors, Fig. 3 shows a two-stage circuit with a current gain of some 1600 times. It employs two transistors, direct-coupled, and each with its own battery supply. When one or two pen-cells make up the whole supply for one stage, there is not much disadvantage in cascaded circuits where each stage has to have its own battery. A somewhat different story from the same sort of thing using 250 volt power packs!

The circuit of Fig. 3 will actually give full-scale reading on a 0–1 ma. meter for input currents of less than one microampere. In our own laboratory, we have already used it as a relay-operating device, in which the relay closed at 10 ma., drawn from a 3 v. battery, and where the input current change was between 6 and 8 microamps. This is an arrangement that has no parallel at all in electrical or electronic history, and is made possible solely by the transistor. Note that in Fig. 3 a backing-off circuit has been used to offset the standing current in the second transistor stage. Such a circuit is necessary because although the collector current for zero input current is very small in the first stage, this current is amplified by the second stage, and is no longer negligible in the collector circuit of the final stage. An ideal application for such a circuit would be as a null indicator for a D.C. Wheatstone Bridge circuit, or for a D.C. potentiometer circuit, for precise measurement of voltage. However, without special circuitry, the drift of such a circuit might be rather too great for comfort.

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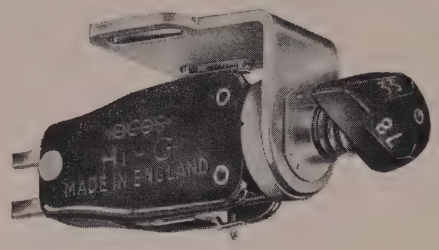


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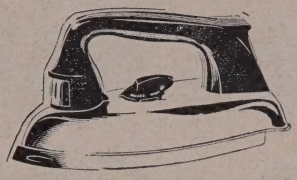

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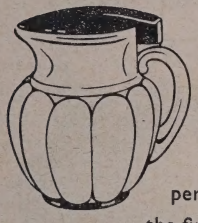

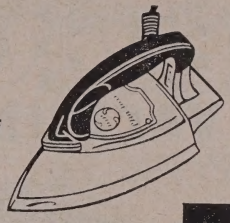

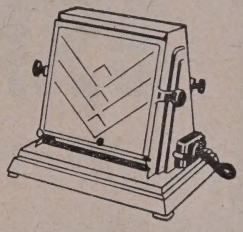

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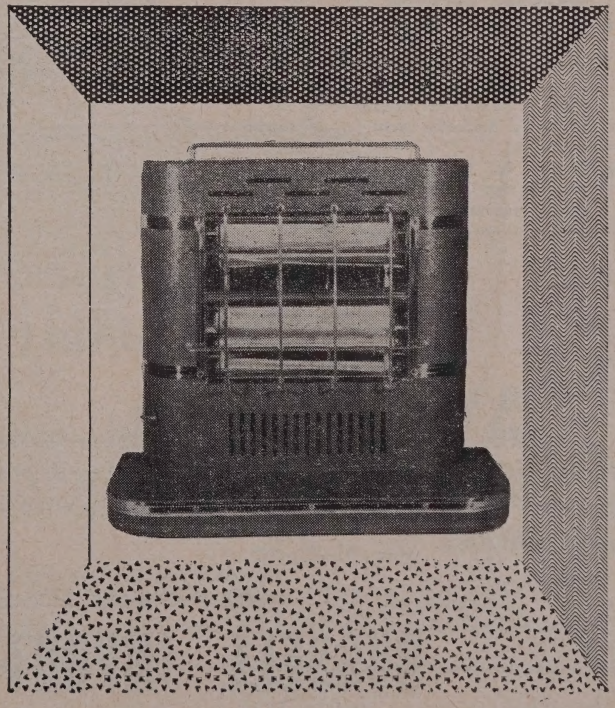

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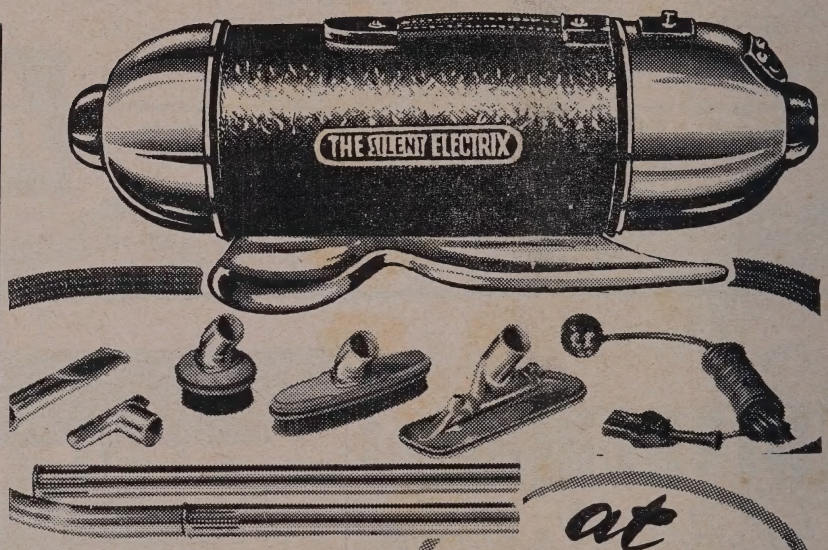


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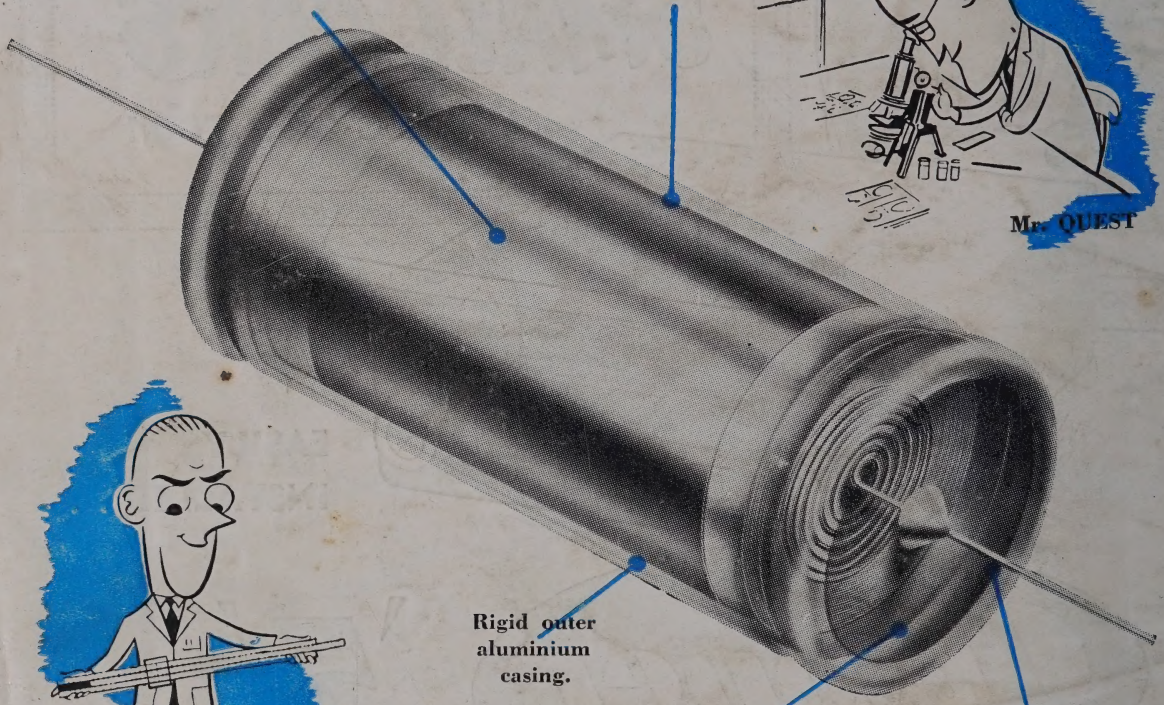

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